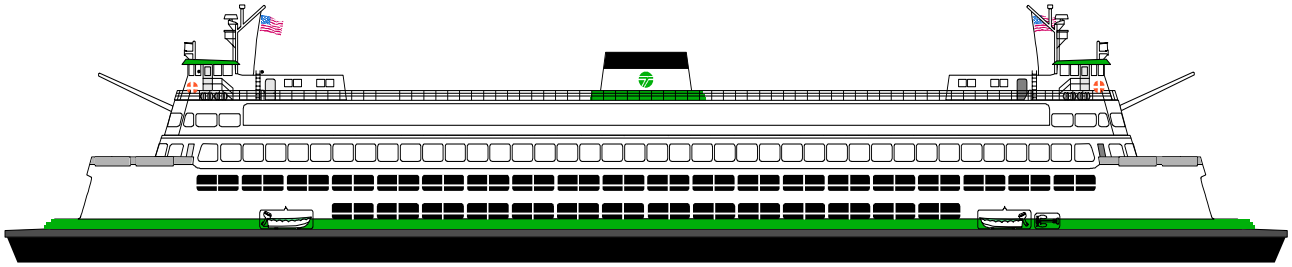

WASHINGTON STATE FERRIES

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

REQUEST FOR PROPOSALS

M.V. ELWHA

PROPULSION CONTROL SYSTEM REPLACEMENT

CONTRACT NO. 00-7171

US FTA # WA-05-0040, WA-90-X364

TECHNICAL SPECIFICATIONS

Volume II

JULY 2006

WASHINGTON STATE FERRIES

M.V. ELWHA
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EXHIBITS

1.0 REFERENCES

All equipment and systems furnished under this contract shall be designed, built and tested according to American Bureau of Shipping (ABS) ACC requirements as well as the requirements of the following publications and references, to the extent they are applicable:

(1) American Bureau of Shipping (ABS) Rules for Building and Classing Steel Vessels.

(2) United States Coast Guard, 46 CFR.

(3) Federal Communications Commission, 47 CFR 15.7.

(4) Instrument Society of America, Standard S18-1.

(5) IEEE Standard No. 45, Recommended Practice for Electrical Installations on Shipboard.

(6) Underwriters Laboratories Inc., (UL) applicable standards for Electrical Equipment and Lighting.

(7) IEEE Standard No. 518, Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources

(8) USCG NVIC No. 2-89, Guide for Electrical Installations on Merchant Vessels & Mobile Offshore Drilling Units.

(9) USCG NVIC 5-82, Guidelines for the Installation of Special Fixed Ballast Materials

(10) USCG NVIC 9-97, - Guide for Structural Fire Protection

2.0 PROJECT INTRODUCTION & BACKGROUND

Washington State Ferries (WSF) is seeking proposals to design and provide a Propulsion Control System Replacement for the Motor Vessel Elwha.

The Contract is for one (1) Propulsion Control System, for the Vessel, as defined in this Technical Specification. The scope of work includes significant engineering, design, project management and local support requirements. The engineering and design efforts includes, but is not limited too, preparation of a Contractor Bid Support (CBS) package for WSF to provide to the shipyards for their use in preparing Bid Proposals for equipment installation competition. Additional engineering and design work will be required to provide detailed technical information for the winning shipyard Contractor to use in equipment installation. Local support is required as defined in this Technical Specification and the Contract to provide project management, contract administration and engineering liaison working with WSF and local shipbuilders to insure efficient, timely and accurate project activity.

Should Proposers need any additional information, please contact the WSF Representative specified in the RFP "Proposal Instructions" document.

3.0 VESSEL CHARACTERISTICS

Washington State Ferries' Vessels typically operate fifty (50) weeks per year on a continuous basis (approximately 6000 hours annually, 16 to 20 hours per day), with a two (2) week annual maintenance period at WSF Eagle Harbor facility. The Vessels are typically at a commercial shipyard for a three (3) week dry-dock availability twice every five (5) years.

The subject Vessel is a welded steel, double-ended ferry, with an approximate lightship displacement of 2704 Tons Lightship Displacement. The Vessel is designed to American Bureau of Shipping standards, the United States Coast Guard, and certificated to transport 2500 passengers and crew, and 160 standard size passenger vehicles on two (2) vehicle decks.

The MV Elwha's current propulsion system is a diesel electric system consisting of one 6600 HP DC motor, a set of series/parallel thyristor converter armature bridges, and a pair of DC digital drives on each end of the vessel. The drives are field-reversing. Propulsion power is supplied by four diesel-generators through a common 600 VAC bus in the propulsion switchboard. Two control handles in each pilothouse are used to individually control the shaft speeds.

4.0 SCOPE OF SUPPLY

This specification describes the Propulsion Control System (PCS) replacement and associated system components for one (1) Super Class ferry MV ELWHA.

All Ross-Hill supplied components of the PCS and the propulsion switchboard are to be replaced unless specified otherwise in the following sections. The intention is to replace all obsolete or unsupportable equipment while reusing the existing enclosures, bus work, circuit breakers, Silicon Controlled Rectifiers (SCR's), and interconnecting cabling where possible. The replacement components will provide, at a minimum, the same functionality and level of redundancy as the original system. Additional new features for enhanced reliability will be spelled out in this specification. The Contractor equipment and systems shall be designed and built for existing conditions on the vessel. Contractor equipment and systems shall include back panels, control modules, console inserts, and other items that must be installed into existing equipment and/or enclosures. For all such items, the contractor shall be wholly responsible for their installation into such existing enclosures.

The new equipment enclosures, externally mounted field supply transformers, or standalone field sensors, shall be supplied to the shipyard designated by WSF as Owner Furnished Equipment (OFE). The shipyard will then be responsible for the physical installation of such standalone Contractor equipment into the ship. The contractor shall be responsible for all internal finish work with such equipment. This will include but not be limited to stripping and termination of all shipyard installed cable and wire.

The Contractor shall be responsible for the technical support for assembly of such standalone delivered equipment and shall cooperate with the shipyard in the installation process. The Contractor shall be responsible to integrate the equipment with other ships systems, to perform commissioning and testing, and for design corrections and final system settings.

The certified vessel vehicle and passenger carrying capacity shall not be reduced as a result of the PCS design. The Contractor shall obtain USCG approval of all applicable drawings, calculations and documents after they have been approved by WSF. The Contractor shall provide copies to WSF of all correspondence with Authoritative Agencies. The Contractor shall carry out all tests and demonstrations required by Authoritative Agencies.

This vessel is not intended to be certified for ABS Class. However, the specification Parts and Sections may include various references to ABS requirements. Where designs, processes, procedures and installation requirements are referred to ABS rules, the contractor shall adhere to the requirements of the applicable ABS rules, but is not required to obtain general ABS approval nor required to have ABS onboard the M/V Elwha for inspection. Certain materials and equipment are indicated to be certified by ABS. Where the term "certification" is used, the contractor shall obtain ABS approval and certification for the noted material or equipment.

It is not the intent of the specification to present or depict all of the minute details of design, construction and/or installation. The Contractor remains wholly responsible to deliver the Propulsion Control System (PCS) complete in all respects and suitable for its intended

service and specified performance, to meet the requirements of this specification and applicable Authoritative Agency requirements.

Unless otherwise specified, all Contractor provided components, structure, and outfit is to be designed to withstand and to properly function under the list, trim, roll and pitch criteria as set forth in ABS and IEEE-45.

The installation of the new PCS standalone items will be provided for under separate contract with a selected shipyard. The Contractor will provide shipyard installation support, testing and commissioning for all such Contractor equipment to be installed.

The WSF Project Manager will be the single point of contact for all oral and written communications.

"Or Equal" Substitution Requirements: With the exception of certain items which have been designated and specified for reasons of commonalty with other Vessels of the Washington State Ferry fleet, names of manufacturers and trade designations of items are mentioned in the Technical Specification only as a means of describing the general function, quality, and construction of the various articles, equipment, or materials.

Subject to the exception noted above, it is not the intention of the Technical Specification to restrict the Contractor to the supply of specific articles, equipment, or materials to the makes or brands so named, but to provide a ready criterion for determining the type, quality, and construction of equipment that will be acceptable.

The substitution of an "or equal" item can only be approved by the WSF Project Manager. Other WSF representatives **do not** possess blanket authority to approve any substitutions. Demonstration of an "or equal" status is the full responsibility of the Contractor.

Requests for substitutions shall: be made in **writing** to WSF's Legal Services / Contracts Development Manager prior to Contract Award, and to the WSF Project Manager after commencement of the Contract; and (ii) set forth the reason for the proposed substitution and providing complete documented evidence that it exhibits all of the following:

1. both a size and weight substantially similar to the product specified in the Contract Documents, to ensure that no adjustment to the equipment arrangement would be required to accommodate the product's inclusion as a substitute into the Vessel(s);

2. its characteristics, performance, reliability, maintainability and other salient features fulfill the requirements of the product identified in the Contract Documents;

3. its total performance will be such that its use will not adversely affect the intended performance or systems of the Vessel(s);

4. its use will cause no increase in required maintenance or cause premature replacement; and

5. its equivalence or superiority to the specified product or material. The request shall also provide the Contractor's assurance that the substitution, if approved, will not result in any increase in the Contract Price nor an extension of the delivery date of the Vessel(s).

The approval of an "or equal" by WSF does not relieve the Contractor of resolving any problems or interferences that result from differences between the specified product and the "equal" product.

Where there is a directed procurement the Contractor shall provide only the specified item. If procurement of this item is impossible because it is no longer available, the Contractor shall request approval of a substitute, in writing, from the WSF Project Manager utilizing the procedure as specified above for “or equal” substitutions.

WSF’s Project Manager will respond to written requests submitted within ten (10) working days of the receipt of the request. The request must include **all** required supporting documentation.

The Contractor shall, to the maximum extent practicable, standardize by minimizing the number of brands of like or similar components used. This applies within a system, across similar systems, and ship-wide for components being provided by this Contract.

Any equipment manufacturing before approval of the Contract Bid Support (CBS) and the detailed design in the Detailed Design Support (DDS) packages required by this Technical Specification by the WSF Representative shall be at the PCS Contractor’s sole risk. Progress payments for manufacturing shall be approved **after** WSF Representative approves the CBS, manufacturing shop drawings and the DDS packages.

Prior to the start of manufacturing, progress payments for advance material purchases may be requested in accordance with the Contract. Requests for advance material purchases progress payments shall be documented by submittal by the PCS Contractor, and approval by the WSF Manager of Purchase Specifications and submittal of invoices for those material purchases.

4.1 Definitions

The following definitions are intended to supplement the Contract Definitions and shall not be construed as replacing or changing the Contract Definitions.

Propulsion Control System (**PCS**)- All equipment, components, material, technical information, design and design support, manuals, spare parts, special tools, panels, consoles, sensors, controls and all other items required for a complete, functional ship's propulsion control plant, including, but not limited to, propulsion switchboard and remote control retrofits, propulsion drive power conversion equipment retrofits, EOS control console modifications, pilothouse control console modifications, propulsion diesel control console modifications, electronics power supplies, and other ancillary equipment as required for a completely functional system.

ALARM & MONITORING SYSTEM (**AMS**)- The existing AMS system shall be retained on the vessel. WSF expects the Contractor's PCS System to alarm all necessary propulsion alarms without the need to interface with a new AMS system.

INTERCHANGEABILITY - The ability of system components, at the "repair level," to be used in every system acquired in the procurement. This ability is present, if and only if, the component requires, at most, an installation adjustment of variable devices (i.e. potentiometers, dip switches, or other digital devices).

PROGRAMMABLE LOGIC CONTROLLER (PLC) – an industrial computer that accepts inputs from switches and sensors, evaluates them using a stored program, and generates outputs to control machines and processes.

ARMATURE CONTROL MODULE (ACM) – The main DC drive control component responsible for the conversion of the AC generated power into the DC output power required for a propulsion motor armature.

FIELD SUPPLY MODULE (FSM) – A secondary AC-DC drive control and power component responsible for the conversion of the AC generated power into the DC output power required for a propulsion motor's field poles.

4.2 Removal Items

The intent of this section is to describe those standalone components and equipment of the existing PCS that are to be removed permanently from the vessel by the shipyard. The shipyard will accomplish all removals of entire pieces of equipment. The responsibility for removal of partial sections from retrofitted PCS equipment shall be the contractor's. The Contractor shall identify in the Contractor Bid Support Package any standalone items designated below for permanent removal that the Contractor desires to reuse. The Contractor shall also identify in the Contractor Bid Support Package any standalone PCS items that are not listed below for permanent removal that the Contractor desires to be removed. This would include items rendered useless or those that become unnecessary due to the Contractor's design.

4.3 Propulsion Generator Set

The existing EMD propulsion generators and their prime movers shall be reused for this control system replacement. Existing Generator anti-condensate heaters shall be incorporated into the new PCS and interlocked with the Generator circuit breaker as well as a selector switch on the Propulsion switchboard.

4.4 Propulsion Switchboard

The Contractor shall modify the existing EOS Propulsion Switchboard . The Propulsion Switchboard shall maintain a minimum rating of 9 kA at 600 VAC, 3-phase, 3-wire, 60Hz, and 75 kA of estimated symmetrical fault current. The final design and layout shall be submitted to the Project Manager for review and approval prior to construction. The front panel arrangement shall include a mimic diagram depicting power flow and shall have indicators for monitoring circuit breaker status (open or closed), propulsion diesels on-line, power available, etc.
The redesigned motor has modified ratings for armature voltage, armature current, and armature torque from the original motor design.

4.5 SCR Static Power Converters

The Contractor shall supply new, Standard Product, Industrial/Marine SCR controllers that shall reuse the existing Ross Hill SCR bridges (bridges with redundant 12-pulse halves, each half consisting of two series-connected 6-pulse bridges). All existing Ross Hill controls responsible for the firing and control of these 24 SCR's shall be replaced in full. Along with reuse of the existing SCR's, bridge bus bar, supports, insulators, and associated, the SCR output contactors and the existing drive isolating/phase-shifting propulsion transformers shall also be reused. Contractor shall maintain the use of the +5% primary taps on the propulsion transformers

4.6 Propulsion Control and Instrument System

The PCS furnished by the contractor shall be a complete, integrated package consisting of all equipment, components, sensors, displays, controls, and other devices required to implement a fully functional propulsion system, including control and instrumentation from and to the propulsion diesel-generators. The system shall be digitally based with redundant PLC controls, including self-diagnostic and automatic changeover (hot backup) functions. All control and transfer functions shall be accomplished using redundant PLC controllers and redundant remote I/O modules, hereinafter called Remote I/O Stations (RIO).

4.7 Vital System Power Supply

The Contractor shall design systems for use of a redundant 24VDC Power Supply and Distribution System. Two battery banks, two battery chargers and two disconnect switches shall be located in two different locations on the lower car deck supplied and installed by the shipyard. Two independent, cross-connected 24VDC distribution panels shall be located in the EOS, supplied and installed by the shipyard, providing dual power sources to each subsystem of the PCS and supporting other vital systems.

4.8 Propulsion Motor

The MV ELWHA has one DC Propulsion Motor at each end of the vessel directly coupled to the propulsion shaft. There are a total of two (2) electrically independent propulsion motors on the vessel.

The existing propulsion motors shall be reused. The motors have been in service since 1967, and were rebuilt by Westinghouse in 1991. The rebuilt motors have a different design from the original motors. This new design does not require interpole equalizer windings. The armature is wound using a fully compensated winding design known as a “frog leg” winding. There is also only one field winding, whereas the original design had two field windings.

4.9 Reliability/Availability

Provide as described in Section 6 of this Technical Specification

4.10 Administration, Plans, and Schedules

Provide as described in Section 7 of this Technical Specification.

4.11 Drawings, Manuals and Software

Provide as described in Section 8 of this Technical Specification.

4.12 Testing

Provide as described in Section 9 of this Technical Specification.

4.13 Training

Provide as described in Section 10 of this Technical Specification.

4.14 Engineering Support

Provide as described in Section 11 of this Technical Specification.

4.15 Spare Parts and Tools

Provide as described in Section 12 of this Technical Specification.

5.0 PROPULSION CONTROL SYSTEM TECHNICAL REQUIREMENTS

5.1 General Description

This Section describes the general requirements for the Contractor provided Propulsion Control System (PCS) and associated equipment, hereinafter referred to as the "PCS". It is the intent of the specification that the successful Contractor design, fabricate and deliver all the equipment necessary to replace the existing PCS and associated equipment. All standalone equipment shall be provided and delivered to a designated shipyard as WSF Owner Furnished Equipment. All partial systems requiring installation into existing vessel equipment and enclosures shall be wholly the responsibility of the contractor. All electrical installations shall comply with **Exhibit 1**. WSF Electrical Installation Specification.

Proposals shall come from a single source and should offer a design and materials that will be maintainable for a minimum twenty (20) year service life. Any modifications required of existing equipment or of the vessel to make the Contractor's PCS fully functional are the responsibility of the Contractor. The shipyard will be required by WSF to install all Contractor standalone equipment, fabricate necessary foundations, pull new cables, land cables into equipment with appropriate stuffing tubes, cable connectors, or MCT's, remove all deleted cabling, setup and perform tests, and perform other tasks as needed by the Contractor. The stripping and terminating of all wire inside each PCS enclosure, new or existing, shall be the responsibility of the contractor. The Contractor shall identify all required shipyard services in the Contractor Bid Support Package. The Contractor shall be responsible for the completion of any work and supply of any materials not identified in the Contractor Bid Support Package, but which are found to be necessary to complete the installation of the Systems or to make the Systems fully functional.

The PCS furnished by the Contractor shall be a complete, integrated package consisting of all machinery, equipment, components, sensors, displays, controls, and other devices required to implement a fully functional propulsion system when combined with existing propulsion equipment specified to be retained and reused. The system shall be digitally based with redundant PLC based controls wherever possible. All control and transfer functions shall be accomplished using redundant PLC's wherever possible. (The control transfer PLC shall be allowed in non-redundant form.)

All sub-systems, equipment and components fabricated, purchased for, or installed in the Contractor Systems shall meet the applicable requirements of 46 CFR (including Subchapter "H" for passenger vessel), ABS Rules for Building and Classing Steel Vessels, and IEEE-45. The system shall include all features and alarms required for USCG certification of remotely controlled systems under 46 CFR, Parts 61 and 62, including the development of the Qualitative Failure Analysis (QFA/FMEA), Design Verification Test Memorandum (DVTM) and the Periodic Safety Test Procedure (PSTP). The system shall also be designed, constructed, tested and installed in accordance with applicable ABS rules for compliance with ACC requirements.

The Contractor shall submit all preliminary and final design data, drawings, calculations and other materials used in the development of the PCS design, for review, comment, and approval by WSF Project Manager. Manufacturing drawings for drives, transformers, consoles, switchboards, control panels, and other assemblies designed, built and supplied by the Contractor or his subcontractors, shall be submitted to WSF Vessel Design for review and approval prior to commencement of manufacturing.

Components requiring an adjustment at time of installation shall not require factory or factory representative adjustment to operate on the vessel. All initial installation adjustment procedures shall be designed with simplicity and expediency as priorities.

The propulsion system required by this Specification shall include, but is not limited to, the following major pieces of equipment and machinery:

1 Propulsion switchboard (retrofitted)

2 SCR Static Power Converters (retrofitted)

3 SCR Cooling Systems (retrofitted)

4 EOS Propulsion Control Console (retrofitted)

5 Pilothouse Propulsion Control Consoles (retrofitted)

5.2 Functional Description

All equipment shall be designed to fit in the space provided with sufficient clearance around equipment to allow maintenance and repair, and to allow for the removal and replacement of equipment components without the need to move any ship's structure, wire ways, piping runs, foundations, or other equipment. The Contractor shall perform detailed ship checks with the assistance of WSF Representatives designated by the WSF Project Manager, and shall work with WSF Vessel Design during the design phase to detect potential interferences and propose a satisfactory resolution to any interference problems. Construction of equipment and enclosures shall not begin prior to submittal of applicable drawings and documents to the WSF Project Manager for review and approval by WSF Vessel Design.

The propulsion system shall operate satisfactorily with the THD (Total Harmonic Distortion) present due to the effects of the drive power converters. The total magnitude of the ripple current (peak-to-peak) content at the propulsion motors expressed in percent of rated-load current shall not exceed 6% at rated load, rated armature voltage and rated base speed, with normal loads and sources connected to the propulsion distribution network.

Propulsion power is generated at 600 VAC, 3ϕ, 3-wire. Major electrical consumers' take their power from ungrounded, delta-connected, 600/480VAC, 3ϕ, 3-wire, 60Hz transformers feeding the ship service switchboard. Secondary distribution (for example, lighting systems) is from120/208VAC, 3ϕ, 4-wire, 60 Hz transformers with wye-connected secondaries and a solidly grounded neutral. Final emergency power is generated at 480VAC, 3ϕ, 3-wire, 60Hz, ungrounded, and delta-connected.

Equipment and components shall operate with an AC voltage variation of +6% to -10%, and with frequency variations of ±5%, for all equipment unless otherwise noted in the specification.

For the purposes of this Section, the average ship service load and the total required propulsion power, as seen from the propulsion motors, are based on ship service electrical load analysis and motor power limitations. See **Table 3-1-1** below for details.

Table 3-1-1

ELHWA	
One Propulsion Motor Power Rating (6600 HP output, 93.4% eff)	**5,272 kW**
Bow, Pulling Power Required (adjusted to 10% of total)	**586 kW**
Stern, Pushing Power Required (adjusted to 90% of total)	**5,272 kW**
Total Propulsion Power Required	**5,858 kW**
Average Ship Service Electrical Load Required	**401 kW**
Total Continuous Power Generation Required (ignoring losses)	**6,258 kW**
Electric Motor Maximum Rated RPM	**180 rpm**
Maximum Torque per One Electric Motor's Output Shaft for Pushing Thrust (ABS shaft rating)	**210,080 ft-lbs**
Maximum Torque per One Electric Motor's Output Shaft for Pushing Thrust (motor rating limit)	**192,573 ft-lbs**
Maximum Torque per One Electric Motor's Output Shaft for Pulling Thrust (thrust bearing pulling limit)	**72,944 ft-lbs**
Total Propulsion Power Available (3 Gen x 2100kW/Gen)*	**6,300 kW**
Total Main Engine BHP Available (3 Eng x 3400BHP/Eng)*	**10,200 BHP**

* Four propulsion diesel generator sets available, switchboard circuit brkr interlock limits to 3 online

NOTE: Motor rating and thrust bearing limitation for different directions must be considered. On MV ELWHA, each motor's shaft power output is limited to 6600 HP at 180 RPM when pushing and 2500 HP when pulling.

Normal operation of the propulsion system shall consist of three (3) propulsion diesel generators paralleled to the common bus of the propulsion switchboard and providing 3-phase power at 600VAC. The load shall be shared equally between the generators actually connected to the bus and power shall be distributed to the various loads through appropriate circuit breakers. The loads shall consist of the propulsion motor drives and a motor generator set and two step-down transformers for a 3-phase, 480VAC distribution network. The propulsion motor drives shall consist of 3-phase, full-wave bridge SCR's configured for 12-pulse operation at the voltage and current ratings of the propulsion system. They shall provide power to the propulsion motors at the proper voltage, current and field strength to control speed and direction of the propulsion motors.

The motors shall normally be operated such that the "pushing" motor at the "stern" will propel the vessel forward. The "pulling" motor at the "bow" is driven in reverse to overcome propeller drag. The motor at each end of the vessel may perform either function, depending on the direction of travel of the vessel.

To stop the vessel, both the "bow" and the "stern" propeller shall be reversed in direction of rotation, with the "bow" propeller providing most of the stopping force. The propulsion system shall be designed to bring the bow propeller to a complete stop from maximum pulling RPM and power as rapidly as possible from the time the propulsion controls (EOS or Pilothouse) are moved from full ahead to either stop or reverse. The new system shall be capable of stopping the shaft in a time period no longer than the current minimum stopping time of the existing system, which shall be verified at a pre-delivery trial.

The new system shall be capable of reversing the shaft speed back to full RPM in a time period no longer than the current minimum acceleration time of the existing system, which shall be verified at a pre-delivery trial. The new system shall also be capable of stopping the vessel in a time period no longer than the current minimum crash-stop time of the existing system, which shall be verified at a pre-delivery trial. The Contractor shall be responsible to provide a system design with the above stated capability, including providing any additional WSF approved equipment necessary to ensure compliance with the stopping and reversal time requirements described above.

There shall be two (2) modes of operation from the Pilothouse propulsion control consoles: Maneuvering Mode and Transit Mode. Maneuvering Mode shall allow separate control of the bow and stern propeller shafts using separate throttle handles. In this mode, both motors operate at full commanded power (up to motor and thrust bearing limitations), with the pushing motor having priority over the pulling motor for available power.

In Maneuvering Mode, the PCS shall allow each shaft to independently obtain commanded speed based on the respective throttle command. Each shaft's speed command shall be maximum shaft RPM multiplied by the throttle position (0-10) divided by 10. The PCS shall output the maximum power available (respective of motor and thrust bearing limitations) to achieve each throttle's speed command. But, exceeding generation power limits will result in the pulling end's power being reduced first. The pulling end's power will be reduced no further than the minimum power necessary to overcome propeller drag as determined by sea trials. Further, the PCS shall allow the bow to consume full power (respective of motor and thrust bearing limitations) in the event of a propulsion failure on the stern end. In the "zero" handle position, the motor drive shall keep the shaft from turning, maintaining effectively zero RPM on the shaft.

Transit Mode shall use only the "stern" throttle handle to control both bow and stern propeller shafts. Transit mode is initiated whenever the bow handle is placed in the full ahead position (from 9.5 to 10 ahead position). In this mode, the bow motor, when pulling, operates at some fraction of the stern motor speed reference, based on a speed relationship table. The exact relationship will be determined empirically during sea trials prior to redelivery of the vessel.

The relationship between the bow and stern speed settings shall be such that the vessel will achieve the greatest speed through the water with the least power and/or the least ships' vibration for the handle position. The bow propeller impedes forward speed if it is locked in position, or even if allowed to free wheel (windmill). If some reverse rotation is applied to the bow propeller, overall power consumption is reduced for a given vessel speed, or higher vessel speed is attained with the same power usage. Whenever the bow throttle handle is taken out of the full ahead position, the PCS shall immediately switch over from Transit Mode control to Maneuvering Mode control. Transit Mode shall be indicated at each pilothouse control station and at the EOS Console. In the event of a propulsion failure on the stern end, the transit mode shall be deactivated and the bow shall operate in maneuvering mode.

The Transit Mode speed ratio between the bow and stern propellers will not necessarily bear a linear relationship to ship speed. The power split between bow and stern may vary within a band over the speed range of the vessel, rather than having a direct linear relationship to ship speed or stern propeller RPM. The Contractor shall provide the flexibility in the control system to adjust this relationship based on empirical data obtained during Sea Trials.

Table 3-1-2 Propulsion Control Modes of Operation

Stern Throttle handle position.	Bow Throttle handle position	OPERATION MODE	Stern Propulsion	Bow Propulsion
0 → 10 (pushing) 10 ← 0 (pulling)	0 → 9 (pulling) 10 ← 0 (pushing)	**MANEUVERING MODE**	Independent control. Stern Throttle controls Stern End, up to the motor, thrust bearing or generation power limits	Independent control. Bow Throttle controls Bow End, up to the motor, thrust bearing or generation power limits
			Exceeding generation power limits will result in pulling end power reduction first.	Exceeding generation power limits will result in pulling end power reduction first.
0 → 10 (pushing) 10 ← 0 (pulling)	in 10 (pulling) in 10 (pulling)	**TRANSIT MODE**	Combined control. Stern Throttle controls both Ends in predetermined ratio (*) up to the motor, thrust bearing or generation power limits	Follows Stern speed commands at preset ratio.
			Exceeding motor or generation power limits will result in speed command reduction (*)	
10 ← 0 (pulling) 0 → 10 (pushing)	0 → 9 (pulling) 10 ← 0 (pushing)	**MANEUVERING MODE**	Independent control. Stern Throttle controls Stern End, up to the motor, trust bearing or generation power limits	Independent control. Bow Throttle controls Bow End, up to the motor, trust bearing or generation power limits
			Exceeding motor or power generation limits will result in simultaneous proportional speed command reduction on both Ends.	Exceeding motor or power generation limits will result in simultaneous proportional speed command reduction on both Ends.

(*) - **Bow and Stern power ratio for Transit Mode of operation will be determined during sea trials for optimum plant operation, like vibration, required speed, and fuel consumption**

Final details of control function implementation shall be agreed upon between WSF Vessel Design and the Contractor during the Contractor design period and shall be approved by WSF Vessel Design prior to construction of the PCS or completion of control software, as applicable

5.2.1 Propulsion Control

Direct control of the propulsion system shall be from the console in the Engineer's Operating Station (EOS) or from either Pilothouse. Only one (1) station shall be in control at any time. The EOS shall be the master control station, having the capability to take control at any time from all other stations. Voice commands between the EOS and either Pilothouse shall be via the existing Mackay maneuvering intercom (Ckt. 2MC) and the existing sound powered phone system (1JV), for normal or emergency use. The existing communication systems are to be retained. With the EOS Console in control, the Engineering watchstander will execute the pilothouse commands (usually via EOT) by operation of the EOS handwheel or EOS emergency manual throttle handles.

The PCS shall limit the rate of change in voltage, current, acceleration and speed of machinery, independent of control handle actuation rate, to prevent damage, overload or stress of machinery components for all modes of operation. The retrofitted SCR bridges shall have full regeneration capability but the PCS shall limit regenerative braking power on deceleration to not exceed the constraints on any system components. Dedicated braking resistors and shaft brakes will not be accepted as means by which to implement regenerative braking.

The motor drive control system or other means provided by the Contractor shall limit maximum applied motor torque under any condition to not exceed maximum design torque of the existing motor shafting and other motor components, existing propeller shafting, all flange couplings, shaft bearings, and foundations. The means provided shall limit applied torque to levels that will not cause mechanical or structural damage to any of the components listed. Shaft thrust shall not exceed the ratings of the existing thrust bearings in either pushing or pulling modes.

The Contractor shall provide system test points for checking signal levels for the entire PCS using standard test equipment, including voltmeters, ammeters and oscilloscopes. Test points shall be provided throughout the PCS that allow operational checks and verification of system operating parameters. Test points shall allow checking parameters while system is on-line, such as the ability to check diesel governor actuator current without shutting down the engine to connect the test device. All test points in the equipment shall be provided with special labels stating their name. “As Built” schematics shall show test points and shall list the normal value or range of values, as well as wave forms if applicable, to be expected at each test point.

5.2.2 Equipment and Components - Specific Requirements

Relative to high reliability and easy repairs, the Contractor's equipment shall be designed to withstand marine conditions, including high vibration occurring frequently during vessel maneuvering. Electrical connections to PC boards shall be a type not sensitive to vibration. If used, card edge connectors shall form a tight mechanical fit and be of the "knife" edge or pin and socket type, rather than a "spring leaf" configuration. Card cage rails shall hold the PC board rigidly in place, but shall not transfer any mechanical strain to the cards.

PC board edge connector "fingers" shall be gold plated. All electrical connectors shall be constructed of materials suitable for a marine environment. Electronic signal connectors shall use gold plated contacts. For equipment and component qualification, WSF requires a quality standard based on the ABS Type Approval Program as required by Part 4, Chapter 9, Section 7 of the 2005 ABS, ("Rules for Building and Classing Steel Vessels, Vessel Systems and Machinery").

5.2.2.1 Pilot lights Switches and Illuminated Indicators

Switches and indicator lights that are part of the existing PCS shall be replaced in kind in the same locations unless indicated otherwise in this specification.

All indicator or pilot lights shall be UL listed. Lighted indicators and push buttons for all interior installations shall be Square D, Class 9001, Type KX, heavy-duty type, or equal. All lights shall be flush or semi-flush mounted and have identifying description or label plates. "Or Equal" devices must be submitted through the WSF Project Manager to WSF Vessel Design for determination of equivalency prior to commencing fabrication of equipment.

All pilot lights shall have a built-in "push-to-test" lamp test feature to allow individual testing of lamps. Where the quantity of lights exceeds five (5), or if the contractor prefers a group test feature, the requirement for built in push-to-test will be waived, but the contractor shall provide a lamp test push button that will test all lamps regardless of current status.

All pilot lights shall use the same lamp type to the greatest extent possible and shall use LED style bulbs. No fixture shall be driven directly by any source greater than 120 Volts, but shall be stepped down to 120 Volts by transformers or converters/transducers, as required. All pilot lights driven from an AC source greater than 24 VAC shall be transformer type fixtures. All pilot lights driven from a DC source greater than 24 VDC shall be resistor type fixtures. Lamps shall be replaceable from the front of the light fixture without the use of special tools.

Lenses shall be color coded to the type of information or status to be displayed. The lens color shall be an integral part of the lens, not a coating or overlay.

Unless otherwise specified or if not available in the LED style bulbs, color coding shall be similar to the following table:

• Flashing Red	Corrective action must be taken. System or equipment inoperative. Potential personnel or equipment hazard.
• Steady Red	Fault condition exists, but has been acknowledged by operator.
• Amber	Marginal condition exists as far as system or equipment effectiveness is concerned. Example: Circuit Breaker Open
• Flashing Green	Condition is satisfactory, automatic circuits complete, ready in Stand-by mode.
• Steady Green	Condition is satisfactory, automatic circuits complete, "Run" condition, system is operating properly.
• White	Informational purposes only. Example: "Power Available".
• Blue	Advisory light when an additional color is necessary. Example: "System is Ready for Operation". (Circuit Breaker Closed)
• Clear	Electrical Ground indicator, Synchrocheck lights

When indicator lights are used in association with motors to indicate motor status and speed, the color coding shall be as follows:

• Green	**Run (single speed)** **High speed (multi-speed)**
• Amber	**Slow speed**
• Blue	**Automatic control enabled**
• White	**Reset or power available**

All pilot lights and other sources of illumination used in the Pilothouses shall have a dimmer device for illumination intensity control at night. Certain alarm indications and status indicators shall be exempt from the dimmer requirement. These indicators shall be identified during the design phase. Illumination shall be grouped as either lamps, meters, or throttles and each grouping shall have a separate non-resistive dimmer device.

Fuses shall provide a direct indication of a blown fuse condition. Indicator lights, pop out pins, and similar direct indicator type fuses shall be used wherever feasible

All magnetically operated relays shall make use of integral relay status indicators, such as pilot light LEDs, to indicate that the relay coil is energized.

5.2.2.2 Meters and Individual Analog Indicators

Meters that are part of the existing PCS shall be replaced in kind in the same locations unless indicated otherwise in this specification.

All new analog gauges and meters in the control spaces shall be electrically driven with no liquid or other pressure piping penetrating the control space boundaries. All gauges and meters shall have static free faces. Sight lines shall be carefully checked to ensure that all gauges and meters are not blocked by equipment that extends above the console surface and that they can be viewed while standing at the console.

All meters installed in the propulsion switchboard, drive cubicles, and at the control consoles, shall be round or rectangular, 4½ inch dial, 250° scale, ± 1% full scale accuracy, switchboard style, transducer rated, and shall conform to ANSI C39.1. Meters shall have jeweled pivots or taut band suspension as appropriate and static free faceplates.

Where many displays are required, but space is limited (i.e., the EOS Console), edge-wise style meters may be used. Edge-wise meters shall be 4½-inch high, vertical mount, and calibrated for ± 1% full-scale accuracy.

Meters on the EOS console shall be flush mounted near eye level on vertical surfaces wherever possible. Meters mounted to angled surfaces shall be normal to the line of sight of the watch stander when standing in a viewing position.

Meter scales shall be white with black lettering and shall have red carêts at maximum or normal values. Pilothouse meter scales shall be black with white lettering and shall have carêts at maximum or normal values. Meters shall be scaled such that normal running indication is at approximately mid-scale. Meters in the Pilothouses shall have non-resistive, dimmable, red internal illumination.

All meters, except those in the Pilothouses, shall be rated for a 50° C ambient temperature, including their associated transducers.

No meter shall be driven by a voltage greater than 120 Volts. Where the voltage potential of the point to be sensed and displayed exceeds 120 Volts, potential transformers or transducers shall be used to reduce the voltage to 120 Volts or less. Where transducers are required, they should be 4-20 ma style and operate from a 24 VDC supply. All meters shall have fuse or mini circuit breaker protection, except for meters fed from CT's or where the driving circuitry is inherently current limiting. All CT's shall be provided with shorting terminal blocks. Zero center or offset zero scale meters, capable of reading in a negative direction, shall be provided where needed or useful, such as motor or shaft RPM, armature current, armature voltage, kW, kVAR, etc.

For monitored parameters with a limited operational range, i.e., generator frequency, insulation resistance and battery voltage, expanded scale meters shall be used. The scale shall be either linear, reduced range, as would be used for frequency (57 to 63 Hz), or non-linear, as would be used for battery voltage (0-20 V low resolution, 20-30 V high resolution,

for a 24 Volt battery). Logarithmic scales (overload protected) shall be used for neutral ground current meters.

Meter lenses shall be clear glass, or polycarbonate, and have an anti-static coating or be static resistant. All meter faces shall be drip-proof at a minimum. Meters installed in the machinery spaces shall be watertight.

Meters and gauges shall be flush mounted in consoles, panels and gauge boards. Displays shall be analog in most cases. Digital displays will be considered for parameters that have little tendency to change during operation, that change very slowly, or that require very high accuracy of indication.

All meters shall be calibrated prior to installation and bear the seal of the calibrating facility and date calibrated. The Contractor shall create a summary meter document which shall carry certification and calibration data and signatures for all meters. This document shall be based on MICROSOFT® EXCEL™ files that can be used by Vessel Operators in future USCG annual inspections.

5.2.2.3 Label Plates

The Contractor shall provide an identifying nameplate or label plate for each piece of new or modified electrical equipment, including junction and connection boxes, and all major components. Operators and indicators, either internal or external associated with this work shall have label plates attached identifying the component and its function as part of the work. Any special operating instructions or precautions that may be required by the new or modified system or equipment shall be included on the label plate or on a separate plate mounted adjacent to the equipment. Special operating instruction or precaution plates shall be worded, or otherwise identified, in a manner that will clearly associate the instructions with the equipment or system to which they are affixed.

Unless otherwise specified or required by rule, regulation or law, nameplates, signs, labels, notices, and similar markings and devices shall be machine engraved phenolic laminate, brass, or stainless steel.

Phenolic laminate label plates shall be engraved no less than $^{1}/_{32}$ inch deep. Unless otherwise specified, all lettering will be no less that $^{3}/_{16}$ inches high, block type letters and numbers. On switch escutcheons, lettering shall be no less than $^{1}/_{8}$ inch high.

The label plates for the EOS Console shall have white letters on a black background or color background as indicated: Yellow - lube oil, Blue - jacket water & potable water, Black - fuel oil, Gray - pressurized air, Red - fire extinguishing, and Green - sea water cooling systems.

Components that have label insertion points provided by the component manufacturer may use the manufacturers recommended labeling method. In those cases where the recommended labeling method uses “printed” inserts, the print must be either embossed on the label or printed in indelible ink. The material the label is printed on must be waterproof. Label plates shall be clearly described in documentation stating the exact label wording,

letter font and size, label material, label dimensions, label location and method of attachment.

Wording shall be clear and concise with a minimum of abbreviation. Abbreviations, when necessary, shall be in strict accordance with MIL-STD-12, Revision E or later. Wording nomenclature, terms and names used for the entire contract shall be unified and determined in the early design stage of the project. They shall be used in a consistent manner in documentation as well as on label plates.

All label plates shall be attached using stainless steel screws, or WSF approved water and oil proof adhesives.

5.2.2.4 Terminal Points

All control wiring terminations shall be made to terminal boards using ring lugs or wire compression caps (ferrules) under compression terminal connections. No termination shall be made using the bare wire end. Spade or fork type wire terminations are not acceptable. No more than two (2) wire terminators shall be placed under each screw of a terminal board exclusive of jumpers. Wire shall not be terminated without wire floaters installed on the wire. Pressure-type terminal blocks shall have no more than (2) conductors terminated per termination point. If additional conductors are required for the circuit, another terminal block shall be added and factory made jumper bars shall be installed between them. It is the Contractor responsibility to provide the correct size terminal block for the application.

Only insulated terminal lugs shall be installed and only a manufacturer's approved controlled-cycle crimping device shall be employed. All terminators shall carry UL listing.

All terminal boards shall have a designation which shall be used in all documentation. The designation shall be installed on the terminal board in a manner appropriate to the terminal board design such as phenolic labels for Kulka-style TB's, permanently marked plastic inserts for DIN rail mounted TB's, etc. Stick-on paper or fabric labels are not acceptable.

Connection space around termination points in the Contractor equipment shall provide sufficient space to allow for easy connection access and use of cable and heat shrink floaters for control cables or boot seals and floaters for power termination points.

5.2.2.5 Installation - Specific Requirements

The Contractor's design shall be based on the existing arrangement of the vessel and will require ship checks to fully verify the design. Minor modifications by the shipyard to the ship structure or ship systems may be acceptable but must be approved by WSF as part of the design process.

The Contractor shall provide all technical data and support engineering necessary for the proper installation and subsequent trials of the propulsion system to WSF Vessel Design and the installer. This shall include technical data required for authoritative agency submittals, foundation design, auxiliary support system design (cooling, exhaust and ventilation,

external electrical power requirements, etc.), all interconnecting cable types for power and control cables, and other information as required by the shipyard to produce installation and as-built documentation.

The Contractor shall develop cable list specifications for individual cables including names and type of cable to be installed to interconnect Contractor equipment, as well as any other cabling required for new or modified systems. This cable shall be supplied and installed by the shipyard. All cable landed by the shipyard on new or existing PCS equipment will be terminated by the contractor. When specifying interconnecting power and control cable types for installation, the Contractor shall use MIL-C-24643, Low Smoke cable whenever possible. When the required cable is not available in the specified MIL Standard, then the Contractor shall specify IEEE Std. 45 cable, or other appropriate cable acceptable to the USCG and ABS. The WSF Representative designated by the WSF Project Manager will consider no other commercial cables. Armored cable shall only be used where it is specifically called for, otherwise, all cable shall be unarmored. All new power cable ampacities shall be selected for operation in a 50°C ambient environment and then derated to 80% of rated ampacity.

Circuits that provide power to PCS equipment that is sensitive to harmonics or voltage spikes shall be provided with filters or surge suppression devices.

Shielded cables shall be specified for control circuits run between control stations, drives, switchboards and remote control locations. This shall apply even when an existing cable is available, but is not shielded. Control, alarm, and other low voltage signals shall not be mixed with power conductors or conductors carrying different voltages in the same cable.

The Contractor's system design shall also include full cable specifications with unique cable designators matching the WSF shipboard cable naming system. Each new or modified piece of cable shall have a unique system or sub-system name.

The shipyard will provide wiring identification floaters for external cabling.

Connection boxes provided by the Contractor for connection of power cables to Contractor equipment shall provide sufficient space to allow use of Contractor supplied cable and heat shrink boot seals inside the connection boxes.

Equipment requiring or specified to have replaceable air filtration shall use a common filter size and style to the maximum extent possible. Filters shall be externally mounted and air flow shall tend to seal the filter to the cabinet structure.

5.3 REMOVAL ITEMS

The intent of this section is to describe those standalone components and equipment of the existing PCS that are to be removed permanently from the vessel by the shipyard. The shipyard will accomplish all removals of entire pieces of equipment. The responsibility for removal of partial sections from retrofitted PCS equipment shall be the contractor's. The Contractor shall identify in the Contractor Bid Support Package any standalone items designated below for permanent removal that the Contractor desires to reuse. The Contractor shall also identify in the Contractor Bid Support Package any standalone PCS items that are not listed below for permanent removal that the Contractor desires to be removed. This would include items rendered useless or those that become unnecessary due to the Contractor's design.

The removals by the shipyard will include all foundations, connections, cables, and appurtenances that will not be reused. The shipyard standalone removal list includes, but it is not limited to, the following items:

1. Power and Control Cabling
2. Motor tachometers

Before installation, the Shipyard will remove designated equipment in various categories. Items removed will be designated by a letter "A", "B", "C", or "D", indicating the following action by the Shipyard:

Category "A" items remain the property of WSF. Shipyard will remove these items carefully, protect from weather and physical damage. Mount the items on skids, pallets, or in containers suitable for shipment. **Category "B"** items remain the property of WSF. Shipyard will remove these items carefully, protect from weather and physical damage, mount on skids, pallets, or in suitable containers and deliver to WSF on the vessel's auto deck when requested to do so or when so directed by the WSF Inspector.

Category "C" items are those items identified in the specification that require the shipyard to carefully remove them from the vessel and store them in a clean, safe, dry area. This storage area shall have sufficient facilities for handling these items to permit WSF inspectors and/or contractor maintenance personnel to move the items for inspection, etc. Some of these items may be required by the specification to be refurbished by the contractor, manufacturer's maintenance and overhaul facility and/or WSF. All category "C" items shall be reinstalled in accordance with the requirements of the specification, not necessarily in the same location as removed from. Some items may not be considered in good enough condition for reuse or economical repair. In these cases the WSF Project Manager will provide WSF-furnished replacements.

Category "D" items become the property of the shipyard to be disposed of as it sees fit and in compliance with all laws, rules, or regulations of cognizant authoritative agencies whether local, State, or Federal.

The Contractor shall provide a detailed list of equipment and power cables that the Contractor desires to reuse (Category C). The list of all propulsion control major components and cables shall be categorized by the Contractor and shall be included with the Contractor's Contractor Bid Support Package. The WSF Project Manager will task WSF Vessel Design to review and approve this list, in whole or in part, in order to plan removal categories for the shipyard specifications. For all reused cables, the Shipyard will inspect and test cable insulation resistance to determine suitability of cable for re-use.

The contractor shall be responsible for numerous removals of existing internal equipment in each refurbished piece of equipment. These items, being the responsibility of the contractor, need not be identified into the above categories. The following is a list of representative items requiring removal by the contractor. The contractor's final design shall be wholly responsible for the final determination of all necessary removal items. Representative removal items include:

SCR cubicles:

- DC modules
- CDM displays
- Armature bridge controller (ABC) board
- Tach feedback PC board
- 1 ph. voltage feedback PC boards
- Armature voltage power resistors
- Armature thyristor firing pulse PC boards
- Field supply thyristors
- Field supply thyristor firing pulse PC boards
- Field supply CT's
- Field supply MOV's
- Field supply shunt
- Field Bridge Interface (FBI) board

Propulsion switchboard, Distribution cubicles:

- System Status boards (not replaced)
- Motor Maximum Speed potentiometer (not replaced)
- Motor Maximum Pulling Voltage potentiometer (not replaced)
- Surge suppressors

Propulsion switchboard, Bus Tie cubicle:

- Battery charger
- Diode bridges

- Allen-Bradley PLC modules

Propulsion switchboard, Generator cubicles:

- AC module
- PC2 4-channel temperature board (not replaced)
- S2 temperature selector switch (not replaced)
- M7 temperature meter (not replaced)

EOS console:

- CDM displays
- Handwheel
- Control handles
- Control transfer PLC's
- Lamp test PC boards
- Potentiometer voltage monitor PC board

Pilothouse consoles:

- Control handles
- Potentiometer voltage monitor boards
- Voltage to current converter PC board

In addition, all transformers, relays, circuit breakers, fuses, fuse holders, terminals, switches, and indicator lights related to the PCS, the EOT system, or the propulsion switchboard will be removed from these cubicles and consoles.

5.4 (RESERVED)

5.5 PROPULSION GENERATOR SET

5.5.1 General Requirements

The existing EMD propulsion generators and their prime movers shall be reused for this control system replacement. Existing Generator anti-condensate heaters shall be incorporated into the new PCS and interlocked with the Generator circuit breaker as well as a selector switch on the Propulsion switchboard.

into the new PCS and interlocked with the Generator circuit breaker as well as a selector switch on the Propulsion switchboard.

5.5.2 Nameplate Data for MV ELWHA

Propulsion Generators:

ELECTRO-MOTIVE DIVISION, GENERAL MOTORS
Model: AB21-6
Output voltage: 600 VAC, 3 phase, 60 Hz
Rated current: 2525A
Rating: 2625 kVA (2100 kW) continuous
Power factor: 0.8
Speed: 900 RPM
Excitation: 75 Volt - 3.2 Amps
Phase rotation 1, 3, 2
Insulation Class: stator - H, rotor - F
ABS & USCG temperature rise above 50°C ambient: 115°C (stator)/ 90°C (rotor)
Subtransient reactance x_d'' = 0.19 pu

Main Engines:

GENERAL MOTORS / ELECTRO-MOTIVE DIVISION
Type 16-645 F7B
2535 kW
3400 BHP continuous, 3740 BHP intermittent
900 RPM

Governors:

WOODWARD EGB-P13 PR

Existing governors are Direct Acting. WSF shall have these governors converted to Reverse Acting by a local Woodward Governor authorized service facility.

5.6 PROPULSION SWITCHBOARD

5.6.1 Propulsion Switchboard - General

The Contractor shall modify the existing EOS Propulsion Switchboard . The Propulsion Switchboard shall maintain a minimum rating of 9 kA at 600 VAC, 3-phase, 3-wire, 60Hz, and 75 kA of estimated symmetrical fault current. The final design and layout shall be reviewed and approved by WSF Vessel Design prior to construction. The front panel arrangement shall include a mimic diagram depicting power flow and shall have indicators for monitoring circuit breaker status (open or closed), propulsion diesels on-line, power available, etc.

Functionality of the existing Propulsion Switchboard shall be maintained except as indicated in this specification.

For propulsion generators, bus-tie, and propulsion motor drives, the propulsion switchboard shall contain draw-out, air frame type circuit breakers with mechanically and electrically charged stored energy operator, both open and closed, controls, indications, ground detection or cable insulation metering, automatic and semi-automatic paralleling capability for diesel-generators, Volt/Amp/Hz/KW/kVAR-metering, Synchroscope, and other devices needed for the operation, control and protection of the propulsion power system shall be provided.

All operation, control, and protection functionality shall be fully operable with the propulsion switchboard 6300A bus-tie switch both open and closed. With the bus-tie switch open, each end's generator and motor control, load sharing, voltage control, and power limiting shall operate independently of the other end's. The bus-tie switch's open or closed status shall be monitored by the PCS system and the LON network shall open or close with the bus-tie switch if necessary for proper operation.

The Contractor shall plan to reuse the existing Merlin Gerin draw-out circuit breakers. Should the contractor reuse the Terasaki breakers in the propulsion switchboard, the contractor shall have these breakers refurbished and tested prior to reuse

The Contractor shall modify the existing propulsion switchboard, located in the EOS. The function of the Propulsion Switchboard shall be to control the propulsion diesel generators in any combination (maximum of three on-line generators) and to distribute power to the propulsion motor drives, MG set and the ship service switchboard. Power will be generated at 600 VAC, 3ϕ, 3W, ungrounded delta for propulsion loads, through the step-down transformers, to 480 VAC, 3ϕ, 3W, ship service switchboard loads, and, through the MG set, to 480 VAC, 3ϕ, 4W loads.

Switchboard sections shall provide the necessary equipment to supply all distribution loads powered from the Propulsion Switchboard. The contractor shall be responsible for properly sizing all circuit breakers in the Propulsion Switchboard, including protective function set points.

Fault current calculations shall be performed at the Propulsion Switchboard, drive units and any circuit affected by the work, to demonstrate maximum fault current conditions, verify that circuit breakers can withstand the current rating, and that current breaking capacities are adequate. When the minimum fault currents are less than the instantaneous trip ratings of the installed protective device, the Contractor shall demonstrate that the cable is adequately protected from long-term, over-current conditions.

The Propulsion Switchboard shall meet all applicable requirements of USCG 46 CFR, Subchapter J (complete) and Subchapter F, Parts 61 and 62, ABS Rules for Building and Classing Steel Vessels, Part 4, IEEE-45, and U.L. Standard 891.

The Propulsion Switchboard shall not require forced ventilation to operate but shall be rated to operate at maximum expected load using convection cooling only in a 40°C environment. The ventilation fan supply to the EOS shall serve the purpose of supplying cooling air.

Molded case circuit breakers shall meet U.L. Standard 489. Circuit breakers shall be calibrated for 50°C where applicable.

The switchboard shall be front accessible, with only limited rear access capability, with hinged, swing out doors on the front having adjustable fasteners to hold the doors open, and bolted panels at the rear with captive fasteners. Doors shall be able to open greater than 90 degrees. Contractor shall provide entire new doors for installation on every cubicle of the switchboard. Contractor shall make all necessary ship checks and measurements of the existing switchboard to ensure form, fit, and function.

Cable entry shall be from the top. Standard ANSI lug holes shall be provided in bus bar for all generators, propulsion drives, bus-tie and other switchboard load cable connections. These bus lug connections shall be easily accessible from the switchboard rear. Lugs shall be made up using silver plated Belleville style washers, or equivalent. The Contractor shall provide safe provisions for connecting external load bank cables to test the generators. All new cables penetrating the Propulsion Switchboard shall be via multi-cable transits (MCTs).

Design and construction shall be in accordance with the Authoritative Agencies, other referenced publications and these Specifications. The switchboard and all components shall be rated for a 40°C ambient temperature.

The AC bus shall be powered from 4 (four) existing diesel driven generators. The generator control sections of the Propulsion Switchboard shall provide circuit breaker protection and voltage control for the generators and manual paralleling and speed control of the diesel generators. In addition, the generator control sections shall provide interlocks and relays for generator anti-condensate heaters.

Four Basler DECS-100 automatic voltage regulators shall be provided, one for each generator. The voltage regulators shall be installed in the propulsion switchboard. The voltage regulators shall be used for voltage regulation and reactive load sharing. A means for manually adjusting the generator base voltage shall be installed in each of the Generator cubicles.

The controls identified below shall be mounted in the appropriate Propulsion Switchboard section. The contractor shall provide sensors, transducers, meters, indicator lights and displays at the Propulsion Switchboard as required to perform normal local/remote operations, maintenance and repair activities. Indicator pilot lights shall be provided for vital status displays of items like generator circuit breaker position, generator power available, generator synchronized to bus, and control.

5.6.2 Propulsion Switchboard – Section Specifics

The generator control sections shall provide circuit breaker protection and voltage control for the generators and semi-automatic paralleling and speed control of the diesel generators. In addition, the generator control sections shall provide interlocks and relays for generator anti-condensate heaters.

The Propulsion Switchboard shall provide generator circuit breaker close permissive status. The circuit breaker enable to close light shall not illuminate until all permissives required to close the generator circuit breaker have been met. These include generator voltage, frequency, phasing and synchronization with the propulsion switchboard that must all be within prescribed limits for paralleling the generator

The generator sections shall contain all necessary instruments and controls for local control of the generators and circuit breakers. It shall be possible to operate each of the four diesel generator's associated switchboard components from a single location.

Switchboard instrumentation and controls shall include the following for each generator (requirements of Authoritative Agencies shall also be incorporated):

1) Off/Low Idle/High Idle/Run 4-position selector switch
2) Low Idle amber pilot light
3) High Idle green pilot light
4) Voltmeter, all phases + bus voltage switch selectable with off position
5) Ammeter, all phases, switch selectable, with off position(s)
6) Kilowatt meter, three-phase
7) KiloVAR meter, three-phase
8) Frequency meter (analog dial with inset LED display)
9) Frequency adjust device - spring return to center switch "Lower -0- Raise"
10) Voltage adjust device, located inside each generator control panel
11) Paralleling Synchroscope (one for all four generators)
12) Generator selector switch (one for all four generators)
13) "Close Circuit Breaker" blue illuminated push button, illumination indicates "Sync" status (one shared device mounted beside synchroscope)
14) "Circuit Breaker Closed" blue illuminated push button, illumination indicates "Sync" status (one for each generator control panel)
15) "Circuit Breaker Open" amber illuminated push button, illumination indicates "Open" status
16) "Ready to Close" white pilot light for each breaker
17) "Circuit Breaker Trip/Reset" red illuminated push button
18) Generator elapsed run-time meter

19) "Mechanical Governor Mode" orange pilot light indicating diesel engine on mechanical governor control
20) Mechanical governor mode selector switch (mechanical vs. electronic, one switch for all four generators, installed on bus-tie cubicle)
21) Voltage regulator cutout switch
22) FR Circuit Shutdown red pilot light
23) Anti-condensate heater energized red pilot light
24) Multi-window alarm display, IDEC SLC Series (to indicate O/V, U/V, O/F, U/F, Phase Imbalance, and Reverse Power trips, electronic governor failure, load controller failure, AVR fault, and other switchboard alarms required of these specifications or of Authoritative Agencies)

Switchboard instrumentation and controls shall include the following for each SCR set (4 total SCR's, requirements of Authoritative Agencies shall also be incorporated):

1) "Circuit Breaker Closed" blue illuminated push button, illumination indicates closed status
2) "Circuit Breaker Open" amber illuminated push button, illumination indicates "Open" status
3) "Ready to Close" white pilot light for each breaker
4) "Circuit Breaker Trip/Reset" red illuminated push button
5) Drive motor elapsed run-time meter

Additionally, switchboard instrumentation and controls shall include the following (requirements of Authoritative Agencies shall also be incorporated):

1) Ground fault indication lights (3) with test push button (one set for the main switchboard bus).
2) Other auxiliary indications required by the Contractor's design.

AC bus surge suppressors in the switchboard Distribution cubicles, the Surge Suppressor lights on the Distribution Cubicles, the generator Temperature meters and Temperature meter switches, and the Bus Power Factor Meter and the power factor circuit board in the Bus Tie cubicle shall not be replaced.

Generator sections shall be segregated from other sections by fire-resistant barriers. Generator control cables shall be separated from each other to the extent possible. Each generator section shall have an automatic relay, a two-pole cutout switch, and an indicator light for the existing generator anti-condensate heater. The generator heater control circuit shall consist of a normally closed voltage sensitive relay with coil fed from the generator side of the generator circuit breaker. The relay shall open when the generator is producing voltage and cause the power to the generator heaters to be disconnected.

The Basler DECS-100 automatic voltage regulator shall be provided in each generator cubicle. It shall have a functional cutout switch, V/Hz regulation curve, and operate properly whether in parallel or single generator operation. All necessary PT's, CT's, and control operators shall be provided and installed into the switchboard to meet the requirements of

both the Basler DECS-100 requirements as well as those of this specification. The voltage regulator shall be operational only when the diesel generator is in the "Run" mode. The regulator shall have kilowatt and kilovar limiting circuitry and be set up for generator voltage three-phase sensing. The regulator shall also be set up for shunt self-excited operation without the provision of a permanent magnet generator. Contractor shall verify during pre-delivery trials that the existing generator's residual magnetism will supply sufficient starting voltage to meet the requirements of the Basler DECS-100's.

The contractor shall be responsible for providing and matching the electronic speed controller to the existing EGB-P13 governor. The engine governors shall be converted from direct-acting to reverse-acting by WSF. A Woodward 2301D digital Electronic Governor control shall be installed in each Generator cubicle. All necessary PT's, CT's, and control operators shall be provided and installed into the switchboard to meet the requirements of both the Woodward 2301D requirements as well as those of this specification. PT's and CT's shall both be configured for three-phase sensing.

Further, a Woodward EGCP-3LS Generator Load Control shall be installed in each Generator cubicle and shall be used for synchronizing, circuit breaker control, engine speed control and engine load sharing. All necessary PT's, CT's, and control operators shall be provided and installed into the switchboard to meet the requirements of both the Woodward EGCP-3LS requirements as well as those of this specification. PT's and CT's shall both be configured for three-phase sensing.

Under normal conditions, generator speed shall be provided by Woodward 2301D independent control. Each electronic controller shall monitor engine speed through Contractor provided redundant magnetic pick-ups and maintain preprogrammed speed. Upon failure of the electronic governor, the EGB-P13 governor remains on ball head speed control maintaining preset maximum mechanical RPM value. In order to increase reliability and sustain parallel operation in the case of electronic control failure of one governor, the Contractor design shall be such that when electronic speed control for one generator fails, all other generator electronic speed controls shall be automatically switched to operate on the mechanical governor.

The Contractor shall provide a mechanical mode generator selector switch for changing diesel governor mode of operation (mechanical vs. electronic). In the mechanical position, all propulsion diesel speeds shall be controlled by the mechanical "ball head" governors. In the electronic position, each propulsion diesel shall be controlled by its own Woodward 2301D and EGCP-3LS with load sharing capabilities

Load sharing between all propulsion generators shall be maintained by a LON network communications link between the EGCP-3LS units. Each unit shall monitor load (KW) for each generator, compare it to its own load, and modify actuator output value in the electronic speed controller to achieve proper load sharing.

Paralleling equipment shall control real and reactive load sharing between generators. If analog devices are used, multi-turn, locking dials shall be used for adjusting voltage and engine speed through the automatic controls. Appropriate means of locking in settings shall be provided for other types of control devices. Reverse power functions shall have inverse

time trips, adjustable from 0-60 seconds, to account for momentary instabilities when paralleling, and for regeneration. Meters for monitoring kW shall be capable of reading reverse power, at least 15% of the positive, full power scale.

Paralleling of generators from the Propulsion Switchboard shall normally be a semi-automatic operation by the operator in the EOS. A synchro-check relay shall be installed and act as a permissive interlock allowing the operator to close the circuit breaker only when phase, frequency, and voltage are matched within allowable limits.

A Crompton combination A. C. Synchrocheck Relay and LED 360° Synchroscope with a generator selector switch shall be provided. As an alternate means of paralleling from the propulsion switchboard, protected push buttons on the generator control sections shall be available to open and close the circuit breakers manually using the synchroscope. The panel-mounted push buttons shall have a protective cover that must be opened prior to operation. Opening the cover shall not require any tool.

All of the alarm stages for remotely controlled generator circuit breakers shall be displayed on a multi-window light module at the Switchboard, and shall have means to acknowledge (reset) locally.

All transducers, sensors and pickups necessary for automatic or manual control functions and for the alarm functions shall be provided by the Contractor unless otherwise stated.

The propulsion switchboard shall provide an interlock to an existing normally open dry contact in the Engine Room No.1 and Engine room No.2 CO_2 flooding system to stop the propulsion diesel engines and simultaneously open the associated circuit breakers on release of CO_2. Also, the generator circuit breaker shall open instantaneously upon an emergency stop of the respective diesel engine.

5.6.2.1 Propulsion Switchboard – Electronic Governor Operating Mode

The Electronic Governor Mode shall be the normal mode of operation. In the Electronic Governor Mode, the Electronic Governor and the Generator Load Control modules are active.

In Electronic Governor Mode, automatic synchronization of a generator to the bus shall take place while the Circuit Breaker Close pushbutton is pressed. The circuit breaker shall close if 1) synchronization is detected or if a dead bus is detected and 2) if the Circuit Breaker Close push button is pressed.

Normal operation is to have three generators on line. The circuit breakers shall be interlocked so that it is not possible to parallel four generators at one time.

In Electronic Governor Mode the Electronic Governors shall regulate the engine speeds isochronously so that the bus frequency is fixed at 60 Hz for any generator load level. The Generator Load Control modules shall provide a speed bias reference to the Electronic Governor in order to load and unload the generators and to share the active power among the generators on line.

A generator being paralleled with other generators shall automatically ramp up the power smoothly after the circuit breaker closes until the power level matches that of the other generators.

A generator being taken off line shall automatically ramp down in power smoothly until the unload threshold is reached at which point the circuit breaker opens.

In Electronic Governor Mode the generators shall operate with constant voltage and shall share the reactive load.

5.6.2.2 Propulsion Switchboard – Mechanical Governor Operating Mode

There shall be a Mechanical Governor Mode of operation in which the Electronic Governor and Generator Load Control modules are not active. In this mode, the engines shall operate in speed droop with the speed controlled by the governor mechanical ballhead speed setting and the droop setting. The speed of an engine shall be controlled by a Raise/Lower three-position switch located on the Generator cubicle doors.

In Mechanical Governor Mode, the generators are synchronized manually and the circuit breaker is closed manually using the Circuit Breaker Close pushbutton. A paralleling relay shall be used to prevent the circuit breaker from closing out of synchronization.

In Mechanical Governor Mode, the Voltage Regulators shall operate with voltage droop.

In Mechanical Governor Mode, the generators paralleled to the bus shall share active and reactive load.

The Mechanical/Electronic Governor switch on the Bus Tie cubicle shall be used to switch all generators between Mechanical Governor Mode and Electronic Governor Mode.

All generators shall automatically switch to Mechanical Governor Mode in the event of a failure of any one of the Electronic Governors or Generator Load Control modules, or the loss of actuator current in one of the actuators.

5.6.3 Generator Power and Current Limiting

Additional generator power and current limiter functions within the Propulsion Control PLC's shall supplement and oversee any power and current limiting functions in the Woodward controllers.

The propulsion generator power and current shall be limited to the generator rated nameplate values by reducing the propulsion motor armature current limit. The reduction in motor current limit shall be controlled so that the generator power and current are maintained close to the rated values as long as the generator overload condition exists.

The motor armature current limit shall also be reduced in the event that the 600V propulsion bus frequency drops below 59 Hz due to main engine overloading.

The propulsion generator regenerative power shall be limited to 15% of the generator rated nameplate value by reducing the propulsion motor regenerative armature current limit. The reduction in motor current limit shall be controlled so that the generator regenerative power is maintained close to 15% of rated power as long as the generator overload condition exists.

Each of the above limiter functions shall become active when any of the described thresholds is exceeded on any one of the propulsion generators and shall not be based on a calculation of the average generator power or current for the plant. The limiter functions shall operate for any number of generators on line.

A light on the EOS console shall illuminate if any of the limiter functions are active.

The existing Ross Hill power limit controllers in the Distribution cubicles shall not be replaced.

Each generator section shall have transducers providing generator power and current feedback to the Propulsion Control PLC's for use in the generator limiting function. The feedback signals to the Propulsion Control PLC's from each generator shall be to a separate remote I/O input device from another generator's transducers.

5.6.4 Ship Service Switchboard Modifications

The Contractor shall modify the existing Ship Service Switchboard to provide all necessary alarms and indication for Shore Power, and the Propulsion Switchboard bus tie.

Shore power is to be monitored for loss of phase, phase reversal and undervoltage. In case of deviation from minimum requirements for shore power, the shore power circuit breaker shall open via 24VDC shunt tip provided with the breaker. Protective functions that provide for the tripping of or the inability to close the shore power circuit breaker shall be alarmed. The alarm relay time delay shall be set to ignore momentary voltage fluctuations that may cause nuisance tripping. The Contractor shall plan all necessary ship checks to verify data of the existing switchboard equipment.

5.6.5 Special Features

Switchboard instruments shall conform to ANSI C39.1, Requirements for Electrical Indicating Instruments. Instruments shall have white dials with black markings.

Instruments shall be drip-proof, semi-flush, 4½-inch, rectangular or circular switchboard style, transformer rated with 250° scale, and accurate to ±1% of full scale. Instruments shall have jeweled pivots or taut band suspension as appropriate. All installed meters shall be provided with individual calibration sticker that include the date of calibration.

Discrete or multifunction Basler, or equal, protection relays shall be used for under/over voltage, under/over frequency, phase unbalance, and reverse power protection. All Switchboard meters shall be Yokogawa.

Switchboard instrumentation shall be arranged such that the top of the meters are not over 72 inches above the deck. Also, center of the top row of the operator devices like selector switches, push buttons and knobs, are not over 67 inches above the deck.

Potential transformers or electronic isolators shall be used for instruments, meters and relays connected to AC circuits over 120 volts. Transformers for voltage regulators shall not be used for other purposes.

Buses to individual feeder circuit breakers shall be verified as having the appropriate size for the frame rating of the circuit breakers, or greater.

All hardware shall be torqued to industry recognized standard values based on fastener material and dimensional considerations. A WSF approved locking means such as Belleville style washers, shall be used at all bus bar joint connections.

Control switches, indicator lights and other operator interface devices shall be U.L. listed and provide NEMA protection to the same or higher degree than the enclosure in which they are mounted. Momentary contact switches shall be push-button style or spring return rotary switches, as appropriate. Maintained contact switches shall be multiple-position, maintained, rotary switches, or “rocker arm” style interlocked push buttons. “Latching” style push on/push off operators shall not be used. Selector switches shall be cam operated type.

Control relays in 24 VDC circuits shall be sealed contacts or provide wiping action and shall have LED status indicators. Open frame contacts shall not be used.

Indicator lights shall be flush or semi-flush mounted and shall have colored lenses to convey the desired information. LED bulbs shall be used. The color shall be integral with the lens and shall not be externally applied. LED's shall be a standard size, with wedge base (PSB) or bayonet type base. Standardization of LED types used throughout the system shall be accomplished to the maximum extent practical.

A lamp test feature shall be installed for all lights. Lights shall be grouped according to function.

SQUARE D brand, or equal, molded case circuit breakers shall be used for all low voltage (120/208 through 600 VAC) distribution within the contractor's scope of supply. All 120 Volt circuits shall use two pole or switched neutral circuit breakers, as appropriate.

WSF will consider alternate proposals for the brand of molded case circuit breakers, but the contractor may substitute another brand only with express WSF approval.

All switchboard wiring shall be neatly formed in groups and supported to the switchboard or run in ducts to avoid chafing due to vibration and shall be labeled as required in Section 5.3.2.4 of this Specification.

All power conductors shall be adequately braced using USCG-approved materials to withstand the maximum possible fault currents.

Identifying label plates shall be provided as required Section 5.3.2.3 of this Specification.

A standard three prong (U ground) 115 VAC power receptacle and internal fluorescent lighting shall be provided inside each individual section to support maintenance and trouble shooting. Power for receptacles and lighting shall be from ships final emergency power, provided by the installer and connected to Contractor terminals. Internal lighting shall be activated by cabinet door switch.

5.6.6 Use of Existing Propulsion Switchboard

The Contractor shall remove all the components of the existing PCS as category "D" material except for those components specified as suitable for reuse in the new PCS. For the reuse of the existing Propulsion Switchboard enclosure and any equipment reused, the Contractor is fully responsible for the switchboard meeting all Authoritative Agency and Spec requirements.

The Contractor shall refurbish the existing eight Merlin Gerin MP30 circuit breakers and one spare through a factory authorized repair facility and have the breakers tested. Breaker shall be inspected and tested, including primary current injection testing of long-time, short-time and instantaneous trips, in accordance with Square D manufacturer's guidelines such as Bulletin No. 0180IB0001R5/01, Pgs. 17-19. Contractor shall supply copies of the factory authorized test reports to the state within 30 days after testing has been concluded. The circuit breakers shall have both local and remote operation. Connect the stored energy operating mechanism and the open and close indications to the temporary emergency power (TEP) or EP24 system. The existing Masterpact circuit breakers shall be modified so that the

breakers automatically recharge after closing. In each remote controlled circuit breaker configuration the Contractor shall provide two (2) N.O. and two (2) N.C. additional spare contacts for future use. The circuit breaker shall have local protected push buttons to open and close it in an emergency as well as provision for remote operation. When the generator circuit breaker is closed, it shall energize a "GENERATOR ON-LINE" indicator light at the pilothouse and EOS consoles.

The Contractor shall develop a circuit breaker coordination study demonstrating fault selectivity.

All hardware shall be corrosion resistant treated in accordance with IEEE -45, Section 2.26. All hardware shall be torqued to industry recognized standard values based on fastener material and dimensional considerations. A WSF approved locking means such as Belleville style washers, shall be used at all bus bar joint connections.

5.6.7 Optional Modification of Propulsion Switchboard

State shall have the option, per separate contract line item, of deleting the above referenced Propulsion Switchboard Modifications per Section 5.6.1 through Section 5.6.6. In such event, contract shall require the optional contract line item as detailed in this section.

The Propulsion Switchboard shall maintain a minimum rating of 9 kA at 600 VAC, 3-phase, 3-wire, 60Hz, and 75 kA of estimated symmetrical fault current. Functionality of the existing Propulsion Switchboard shall be maintained except as indicated in this specification.

All operation, control, and protection functionality shall be fully operable with the propulsion switchboard 6300A bus-tie switch both open and closed. With the bus-tie switch open, each end's generator and motor control, load sharing, voltage control, and power limiting shall operate independently of the other end's. The bus-tie switch's open or closed status shall be monitored by the PCS system and the LON network shall open or close with the bus-tie switch if necessary for proper operation.

Fault current calculations shall be performed at the Propulsion Switchboard, drive units and any circuit affected by the work, to demonstrate maximum fault current conditions, verify that circuit breakers can withstand the current rating, and that current breaking capacities are adequate.

Contractor shall install into the switchboard or adjoining panels all necessary power, control, and alarm monitoring provisions to enable the new PCS control system to maintain and coordinate control of the entire plant while reusing the existing Ross Hill switchboard controls. Such an interface shall include all requirements from other portions of spec other than C.4.a.1 through C.4.e including all necessary approvals from regulatory bodies. Contractor shall install into the existing switchboard any operator devices and control circuits to meet other portions of the spec or the requirements of all regulatory bodies. Contractor shall include all work associated in both their Contractor Bid Support (CBS) package and design drawing package to the state for approval and prior to manufacturing in accordance with other sections of this document.

The propulsion generator power and current shall be limited to the generator rated nameplate values by reducing the propulsion motor armature current limit. The reduction in motor current limit shall be controlled so that the generator power and current are maintained close to the rated values as long as the generator overload condition exists.

The motor armature current limit shall also be reduced in the event that the 600V propulsion bus frequency drops below 59 Hz due to main engine overloading.

The propulsion generator regenerative power shall be limited to 15% of the generator rated nameplate value by reducing the propulsion motor regenerative armature current limit. The reduction in motor current limit shall be controlled so that the generator regenerative power is maintained close to 15% of rated power as long as the generator overload condition exists.

Each of the above limiter functions shall become active when any of the described thresholds is exceeded on any one of the propulsion generators and shall not be based on a calculation of the average generator power or current for the plant. The limiter functions shall operate for any number of generators on line.

A light on the EOS console shall illuminate if any of the limiter functions are active.

Each generator section shall have transducers providing generator power and current feedback to the Propulsion Control PLC's for use in the generator limiting function. The feedback signals to the Propulsion Control PLC's from each generator shall be to a separate remote I/O input device from separate sets of generator transducers.

The existing power limit control link between switchboard and drives shall be reused as referenced by Ross Hill drawing 6175-017-03 and other relative Ross Hill drawings. Contractor shall design an interface circuit or system that can convert the signal interface from the Ross Hill supplied non standard analog values into an industry standard 4-20mA, 0-10VDC, or similar signal for proper interfacing into contractors supplied drive systems. As shown on 6175-017-03, contractor shall retain and reuse circuit boards PC14 and everything upstream but eliminate circuit boards PC7 and everything downstream from them.

Contractor shall remove the mimic status boards from the switchboard SCR cubicles deleting the LED's and associated wiring as necessary to maintain functionality of the switchboard. Reference Ross Hill drawing 6175-015-01, sheets 1-4, and related Ross Hill drawings. The same status information shall be provided on the operator stations at the EOS and the drive cubicles.

Contractor shall remove the motor power and module select switches from the switchboard SCR cubicles deleting the associated wiring as necessary to maintain functionality of the switchboard. Reference Ross Hill drawing 6175-015-01, sheets 1-4, 6175-015-05, sheet 1, and related Ross Hill drawings. Similar selector switches shall be provided new on the EOS console as part of the contractor's responsibility.

Contractor shall remove the Max Pulling Voltage and Max Motor Speed potentiometers from the switchboard SCR cubicles deleting the associated wiring as necessary to maintain

functionality of the switchboard. Reference Ross Hill drawing 6175-015-02, sheet 2, and related Ross Hill drawings.

For all removal items described above in this section, contractor shall install NEMA12 operator plugs or cover plates painted to match the console for all operators removed.

Contractor shall reuse or replace the existing armature volts, armature amps, field volts, field amps, and motor horsepower meters on the switchboard SCR cubicles. Contractor shall reuse or replace wiring and terminals as necessary. Reference Ross Hill drawing 6175-015-06, sheets 1 & 2, 6175-022-00, sheet 2, and related Ross Hill drawings.

Contractor shall reuse or replace circuit breakers CB2 & CB7 (SCR1 & 2 Aux) in the bus tie cubicle to supply power to field supply modules 1A and 2A. Replaced breakers shall be

Contractor shall work with WSF in identifying a location in the propulsion switchboard, ship service switchboard, or in machinery space distribution panels for new circuit breakers to provide power for field supply modules 1B and 2B and all four circuit breakers feeding the SCR cooling systems.

Contractor shall modify the IDEC alarm panels in the bus tie and their associated PLC's as necessary to delete only those alarms referencing the propulsion motors, SCR's, or SCR cooling system. Contractor shall remove or modify the text in each such light cell and relabel as spare. Contractor shall modify the existing Allen-Bradley SLC500 PLC code as necessary to eliminate those alarms being incorporated into the new PCS PLC system. In all cases, any overridden/bypassed alarms shall be replaced in the new PCS system to report on the new EOS and SCR operator stations.

Contractor shall modify or replace the temperature selector switches to remove the position for motor RTD temp in Generator cubicles 2 & 3. Contractor shall remove wiring, terminals and modify nameplates as necessary. Reference Ross Hill drawing 6175-017-01, sheet 1 and related Ross Hill drawings. Contractor shall incorporate the monitoring, display, and alarming of the motor RTD's in the new PCS. Both temperature level and alarms shall report on the new EOS and SCR operator stations. The Contractor shall refurbish the existing eight Merlin Gerin MP30 circuit breakers and one spare through a factory authorized repair facility and have the breakers retested. Breaker shall be inspected and tested, including primary current injection testing of long-time, short-time and instantaneous trips, in accordance with Square D manufacturer's guidelines such as Bulletin No. 0180IB0001R5/01, Pgs. 17-19. Contractor shall supply copies of the factory authorized test reports to the state within 30 days after testing has been concluded. These existing Masterpact circuit breakers shall be modified so that the breakers automatically recharge after closing. Contractor shall delete and plug the switchboard mounted circuit breaker charged illuminated pushbuttons and shall remove or modify wiring and associated circuitry associated with these circuits. Reference Ross Hill drawing 6175-017-01, sheet 2, and 6175-015-08, sheets 1 & 2, and related Ross Hill drawings. In each refurbished circuit breaker, the Contractor shall have the factory authorized repair facility install two (2) N.O. and two (2) N.C. additional spare contacts for future use.

5.7 SCR STATIC POWER CONVERTERS

5.7.1 General Requirements

The Contractor shall supply new, Standard Product, Industrial/Marine SCR controllers that shall reuse the existing Ross Hill SCR bridges (bridges with redundant 12-pulse halves, each half consisting of two series-connected 6-pulse bridges). All existing Ross Hill controls responsible for the firing and control of these 24 SCR's shall be replaced in full. Along with reuse of the existing SCR's, bridge bus bar, supports, insulators, and associated, the SCR output contactors and the existing drive isolating/phase-shifting propulsion transformers shall also be reused. Contractor shall maintain the use of the +5% primary taps on the propulsion transformers.

Maximum armature current limit, maximum armature voltage, maximum shaft speed, maximum field current, and field weakening characteristics shall serve as the basis for the modified system. Contractor shall design their system as much as practical to replicate the existing Ross Hill motor voltage vs. speed curve. The present system ramps up to motor nameplate voltage at roughly 137RPM. From approximately 137 to 180RPM, contractor shall employ field weakening to achieve higher speeds.

Contractor shall be responsible that their design, installation, and commissioning of this new control system shall provide for full rated continuous load of the associated propulsion motor as spelled out in Section 5.8 . Contractor shall ensure that field and armature speed control and power output meets or exceeds the present operational capabilities of these SCR's. The drives shall be capable of full four quadrant operation.

It shall be possible for either of the propulsion motors to be operated in a half power mode using only one of the two parallel converter bridge circuits in the event that a fault exists in the other branch. All operation, control, and protection functionality required elsewhere in this specification for the combined drive halves shall be maintained for half power mode as well.

The SCR controls shall be standard product, industrial/marine, digital control, SCR-DC controllers that have ABS type certification for this application or shall obtain ABS certification prior to installation. The control unit shall be microprocessor based and fully digital. A modular approach to user (application) software shall be employed.

The drives shall reverse the propulsion motors by way of field current reversal. The units shall have the capability to store in controller memory, plant and drive conditions leading up to a fault to assist in later trouble shooting.

External control electronics and electronics power supplies shall have full redundancy, such that there is no loss in capability nor function of the converter or motor if a single control component or assembly should fail

The propulsion system must work on the power available from the propulsion bus and other sources available. The motors must commutate successfully without excessive sparking, arcing or brush wear. DC current ripple content shall not exceed 6% (peak-to-peak) as

defined by ANSI Standard MG-1. The Contractor shall consider these requirements early in the design and shall notify WSF through the detailed design submittal on how these commutation goals will be achieved.

5.7.2 Static Power Converters

The existing drive cabinets shall be reused with necessary modifications performed by the contractor. Any new panels, doors, cable entrances, operator devices, and the like shall be NEMA 12 construction. The SCR water cooled loops shall be upgraded per the appropriate section of this specification. Any control component cooling required shall be via forced air. The cabinets shall be front only access, unless adequate clearance can be provided at sides and backs of cabinets for access. If rear access is required, small, easily removable panels with captive screws, or doors with open retention devices, shall be installed on the back of the cabinets.

The equipment shall be designed for full load, continuous operation in a 50° C ambient environment. Contractor shall develop a heat load calculation for the SCR cabinets and submit it to the state with the detailed design submittal for review and approval prior to manufacturing. If data cannot be obtained for reused portions of the Ross Hill drive lineups, contractor shall instead calculate the net heat load gain or loss based off of the heat load of removed items compared with those new items being added. Contractor shall then submit this net heat load calculation to the state for review and approval prior to manufacturing.

Each drive half shall be capable of 3000 amperes at full rated voltage on a continuous basis and shall have overload and instantaneous overcurrent protection.

The drive control logic, manual adjustments, instrumentation and alarms shall be located in the drive cabinets.

Motor speed regulation shall be provided by digital circuitry (with A/D and D/A converter circuitry where required) meeting the following requirements:

- Field current control.
- Loss of speed signal shall not result in loss of propulsion control.
- Armature voltage control.
- Speed/voltage control.
- Regenerative braking.
- Acceleration and deceleration ramps shall be included. Each ramp shall be independently adjustable, with multiple ramp step adjustments available. The internal drive ramps may be set as limiters, with normal ramp control coming from the external PCS PLC's.
- Load sharing feature to ensure both drive halves, working with the same motor, are equally loaded.

The propulsion motor drives shall be capable of limiting the maximum torque generated in the propulsion motors through normal control techniques and by means of quick acting

current limiting devices, as necessary, to limit generated motor torque to levels that will not exceed equipment ratings under any operating or system fault condition.

Armature current limits shall be reduced dynamically from the maximum value in response to the generator power and current limiters, and to the motor torque limiter. The relationship between firing angles for the delta and wye 12-pulse bridges shall remain the same as the existing system. Power for the new Armature thyristor firing pulse PC boards shall be self-fed from the same 375VAC feed for the armature SCR's themselves.

The drives and associated electronics shall not produce radio interference exceeding the requirements of the FCC, or interference with properly installed ship's radios, radar, public address and interior communications equipment.

NOTE: All 120 VAC loads, including radios, radars, P.A. systems, and other I.C. systems, will receive electrical power originating from the 600 VAC propulsion switchboard through the vessel's normal 480V distribution network.

Each drive half cabinet (Drive halves 1A, 1B, 2A, and 2B) shall contain, as a minimum, the following instrumentation and controls on its panel face:

- Circuit Breaker Open Pilot Light
- Circuit Breaker Closed Illuminated Push Button
- Push to Trip Push Button
- Motor Lockout Push Button
- DC Module Reset Push Button
- cabinet blower motor control and indication (if forced air cooling is required)
- Operator Panel, 10" Color Display, with integral keypad

The generator circuit breaker Charge illuminated pushbuttons on the Generator cubicles shall be removed and not be replaced. The SCR circuit breaker Charge illuminated pushbuttons on the SCR cubicles shall be removed and not be replaced.

A self test diagnostics system and display shall be located within the drive control section. The system shall include lamps, meters and alpha-numeric displays that will provide operating personnel a means to rapidly identify failed components, sub-assemblies and interconnections to enhance the availability of the propulsion and control systems. A failed component or sub-assembly is one that experiences a loss of any function. This system is not intended to replace or duplicate status indicators and alarms mentioned elsewhere, but will be used in conjunction with other indications during troubleshooting. It is acceptable, however, that some of the indicators mentioned elsewhere, such as mimic panels, may be incorporated in this system.

The contractor shall provide sensors, transducers, and displays at the drive cubicles as required to perform normal local operation, maintenance and repair activities. Sensors shall be provided by the contractor as needed to monitor the various functions.

All new and modified portions of the converter bridges and controls shall adhere to the provisions of CFR Title 46, specifically Subpart 133. Attention should be paid to the

requirements of Subpart 133-11 and its reference to ABS Rules for Building and Classing Steel Vessels (1996) sections 4/5D2.17.9 and 4/5D2.17.10 including the required testing and inspection in the presence of an ABS Surveyor. Contractor shall obtain ABS certification for the refurbished SCR drive cubicles. Any limitations upon ABS certification for all new or modified portions of the SCR cubicles shall be those specified in writing by the ABS Surveyor. Copies of all correspondence, test memorandum, and the final letter(s) of certification between ABS and the contractor shall be submitted to the WSF Project Manager prior to equipment being installed on the vessel.

A high temperature of each SCR bridge half shall be alarmed in two stages to allow for manual load reduction. An additional temperature sensor shall be installed in each drive enclosure to monitor and alarm remotely the drive internal temperature. Any necessary forced air cooling of control cabinets and devices shall be arranged to prevent entry of contaminants in the drive enclosure. Such forced air cooling shall have sufficient redundancy to allow continued operation of that propulsion motor drive at full capacity after the loss of one cooling fan. Power for control cabinet cooling fan motors shall be from the drive input power to provide a self contained system.

Automatic, thermostatically controlled electric heaters shall be installed in converter cabinets to prevent condensation forming when the propulsion system is shut down. Power shall be 120 or 480 VAC from the Ships Service distribution.

Drive cabinet components shall be arranged to be easily removed and replaced. This includes fuses, regulator modules, printed circuit boards, contactors, motor controllers, chokes, reactors, and other components that are intended to be maintainable or replaceable. Cabinet construction, equipment features, instruments, labels, wiring practices and cabinet finish shall be as required elsewhere in this specification.

Standard 15A, three prong (U ground) 115VAC power receptacles and internal fluorescent lighting shall be provided inside each individual section to support maintenance and trouble shooting. Power for these receptacles and lighting shall be from ship final emergency power, 120VAC cables provided by the shipyard and connected to Contractor terminals. Internal lighting shall be activated by cabinet door switches.

5.7.3 Reuse of Existing SCR Bridges

Contractor shall clean and refurbish the existing SCR bridges. Contractor shall test all existing SCR's. Contractor shall replace any SCR that does not pass inspection with available spare stock currently on the vessel.

Contractor shall reuse the existing Cutler Hammer armature output contactors. Contractor shall refurbish and test armature output contactors. At the beginning of the installation process, contractor shall inspect both the main and arcing contacts for signs of pitting, scaring, or other damage. Any such damage found shall be reported to the WSF Project Manager via Contract Report (CR). WSF Project Manager shall, at his discretion, direct contractor to purchase replacement contacts at state expense. Contractor shall then be responsible for replacement of such damaged contactor contacts.

5.7.4.1 SCR Cooling System Refurbishment

The Contractor shall refurbish the existing SCR cooling system on both ends of the vessel and provide certain modifications as described in this section to improve operational reliability. General information regarding the existing system is contained in Sections 2-2.5, 2-3.2, 3-4, 3-5, 4-3, Fig. 3-29A, and Fig. 3-30 of "Marine Propulsion System SCR Drive Technical Manual," Ross Hill Controls, RHCC No. 6175., as well as Ross Hill Controls Dwg. No. 20156-75; Piping- 12 Pulse, 2 Filter, 1 DI Tank, Remote Heat Exchanger. Not included in the specified refurbishment are the existing portions of the SCR cooling system between the flexible hose/steel piping connectors external of the pump cubicle and the seawater heat exchangers (to be conducted under separate shipyard contract in accordance with WSF Dwg. 8204-669-058-01, SCR Cooling System Mods). Basic system functionality, including operating parameters and alarm values, shall remain unchanged.

All workmanship, materials, and equipment shall be in accordance with 46 CFR, ABS Rules, and other applicable requirements as set forth elsewhere in these specifications.

The SCR cooling system refurbishment is to be addressed in the Master System Manufacturing Schedule (MSMS) as described in Section 7 of the specifications. The Contractor shall prepare a detailed installation drawing for the refurbished system in accordance with Section 8 of the specifications and submit to the WSF Project Manager for review no more than 60 days after the award of this contract. Following receipt and incorporation of WSF comments, the Contractor shall submit the drawing to the USCG for approval. USCG approval of the installation drawing is required prior to conducting any work on the system. ABS class approval is not required.

All existing PVC piping, flexible hose, valves, and miscellaneous fittings inside the pump and SCR cubicles are to be replaced with new. Wherever flexible hose is necessary, permanent crimped swivel connectors (Dayco BW Series 316 Stainless Style FJ-SS, or equal) with appropriate adapters retrofitted to connected components are to be used. New PVC piping is to be Schedule 80; new flexible hose, Parker MPT II Series 7094 or equal; new PVC ball valves, Plast-O-Matic Series MBV or equal.

Replace all existing pressure gages, temperature gages, and sensors with in-kind or equal unless specified elsewhere. Wherever a gage or sensor requires duplication to accomplish described system modifications, the duplicate gage or sensor shall be the same as its counterpart.

Replace the existing SCR cooling pump & motor assemblies (Goulds G&L Series Model NPE/1ST, 2 HP, 3450 RPM) with new units of the same make and model within the existing pump cubicle. Retain the removed pump & motor assemblies and deliver to the vessel's Staff Chief Engineer. Replace the existing pump suction strainers with the same or equal. Remove the existing pump discharge shuttle valve and replace with the same or equal.

Replace the deionizer (DI) tank circuit within the existing pump cubicle with the same or equal components and modify to provide for a second deionizer tank parallel to existing. The new, parallel circuit shall duplicate the following: DI tank inlet filter, resistivity probe, DI tank, and DI tank outlet filter. Rearrange components within the existing pump cubicle as required to accommodate installation of the parallel circuit while preserving overall equipment accessibility. Install new ball isolating valves in a manner that permits either circuit (DI tank, inlet & outlet filters, and resistivity probe) to be on-line while the other remains in back-up mode. Install new resistivity probes as described later in this section of the specifications.

Remove the existing pressure reservoir for a visual inspection, cleaning, and hydrostatic testing. Submit an inspection and testing report to the WSF Inspector, and reinstall inside the existing pump cubicle.

Fabricate a new, bulkhead-mounted enclosure for the nitrogen equipment and install at a suitable location near the existing pump cubicle. Provide a drawing sufficient for the shipyard to fabricate and install all required foundations, mounting brackets, etc. for the new enclosure. Submittal of the foundation drawing shall be in accordance with the MSMS. New enclosure is to be fabricated from galvanized sheet steel, suitably sized, with a hinged, latched front panel for access to internal equipment, and finished to match the existing pump cubicle. Remove the existing nitrogen bottle, on-bottle regulator, and nitrogen control box with associated components from the existing pump cubicle for reinstallation in the new, bulkhead-mounted enclosure. Provide a duplicate nitrogen bottle and on-bottle regulator within the new enclosure. Reconfigure the nitrogen supply lines to the control box regulator via new isolating valves in a manner that permits either bottle to be on-line while the other remains in back-up mode. The intention is for both bottles to be simultaneously connected to the reconfigured system while allowing for manual, in-service switch-over between bottles. All equipment within the new enclosure is to be properly supported and arranged for accessibility. New tubing from the relocated control box to the pressure reservoir inside the existing pump enclosure is to be seamless 304 S.S. with compression fittings, and routed through a steel protective conduit between the new nitrogen equipment enclosure and the existing pump enclosure. New protective conduit for the nitrogen tubing is to be routed along bulkheads & the overhead with a minimum number of bends, and positively restrained with hangers.

Remove the SCR coolant supply & return distribution manifolds inside the existing SCR cubicles and replace with new manifolds (the same or equal) in the new SCR cubicles.

Replacement manifolds shall be positively restrained similar to existing. Install new ball isolating valves at the inlet & outlet of each manifold. Also, install a new bypass line with ball valve around each manifold. Manifolds and valves within the new SCR cubicles shall be configured for accessibility.

Following completion of system refurbishment, conduct hydrostatic and system operational testing in accordance with the test memo required per Section 9 of these specifications.

A cooling pump power failure input to the PCS shall be provided for each SCR cooling pump. Each ends cooling system shall supply low water level alarm into the PCS. Each cooling water loop shall provide alarms for low and low-low resistivity, high and high-high cooling water temperature, and low and low-low pressure. A single analog measuring device may replace each pair of dual-staged alarm switches at contractor's option. Should analog sensors be used, dual-staged alarming shall be provided in software.

The present resistivity sensors and metering shall be replaced with new. The new resistivity meters shall read in MΩ/cm rather than percent. The new resistivity meters shall have alarm indications integral with their meter face or be installed by contractor in the immediate vicinity of the new resistivity meters.

AC power for each SCR Cooling System shall be fed from separate main switchboard circuit breakers, separate transformers, and separate cabling. Main Propulsion switchboard circuit breakers shall be either Square D Type FI or KI breakers, or equal, that shall have a minimum fault current rating of 100kA. Each circuit breaker shall be equipped with a padlock lockout bracket. Any removable covers shall accommodate the padlock device. The installation shall consist of a dead front panel to which the circuit breaker shall mount and extend thru pattern cut outs located on the dead front. Provisions shall be made on the dead front panel to provide terminal blocks located to make up all auxiliary circuit breaker connections.

5.7.4.2 Optional Refurbishment of SCR Cooling System

State shall have the option, per separate contract line item, of deleting the above referenced SCR Cooling System Refurbishment per Section 5.7.4.1. In such event, contract shall require the optional contract line item as detailed in this section.

Contractor shall install into the existing Ross Hill SCR cooling system or adjoining panels all necessary power, control, and alarm monitoring provisions to enable the new PCS control system to control and monitor the cooling of the armature SCR's by reusing the existing Ross Hill water cooling system. Such an interface shall include all requirements from other portions of spec other than 3.5.4.1 including all necessary approvals from regulatory bodies. Contractor shall install into the existing pump cubicles any operator devices and control circuits to meet other portions of the spec or the requirements of all regulatory bodies. Contractor shall include all work associated in both their Contractor Bid Support (CBS) package and design drawing package to the state for approval and prior to manufacturing in accordance with other sections of this document.

Contractor shall reuse the Ross Hill SCR water cooling system between pump cubicles and drives as referenced by Ross Hill drawing 6175-022-00, sheets 1 & 2, 6175-023-00, and 20156-75 and other relative Ross Hill drawings.

Contractor shall remove, as shown on 6175-022-00, sheet 1, all wiring upstream of CB3 (15A) feeding the SCR system and all wiring from spools 1-3 and CB1 (60A) and downstream as part of the old field supply removal. Contractor shall remove CB1 (60A), fuses F1, 2, 18, & 19, RL1, contactor K1, the field assigned circuit of relay RL5, diodes D1, D2, & D3, resistor R1, and associated wiring and terminals, and resistors R6 & R7 (310Ω each, found on sheet 2 of 6175-022-00) installed in each pump side enclosure mounted to each pump cubicle. Contractor shall remove any other devices, wiring, and terminals not associated with the SCR cooling system but part of Ross Hill control system removal similar to those just described. Contractor shall land one SCR cooling system feed cable to the input side of CB3 and the other to terminals 11-1 thru 11-3.

During removal of the old field supply SCR's, contractor shall remove the field supply SCR cooling loop tubing back to the supply and return manifolds. Contractor shall plug any necessary ports with appropriate means to maintain full functionality of the existing system. The spare drive cubicle in the WSF warehouse or onboard spares can be provided to the contractor for inspection of tubing types, manifold fittings and thread sizes, and related to appropriately plan this work.

Contractor shall remove the existing Allen-Bradley SLC500 remote I/O modules in each SCR cooling pump end cabinet and incorporate all alarms handled by these A-B remote I/O modules into the new PCS alarm system.

5.7.5 Armature Control Modules (ACM's)

Each Ross Hill DC module shall be replaced with an Armature Control Module (ACM). Each ACM will be paired with its own PCS PLC. Each pair of ACM and PCS PLC will switch with the other ACM-PCS PLC in concert, whether due to failure of either the ACM or PCS PLC or whether because of a manual transfer initiated by operators.

The ACM's shall be Avtron ADDvantage 32 Firing Module (AFM), Siemens Simoreg 6RA70 CM control module, or equal.

In normal operation, only one ACM shall be active. The active ACM shall provide firing pulses to all four existing armature bridges for the motor at that ship end. The firing pulses from each ACM shall be supplied to the armature thyristor bridges through a set of firing pulse switchover modules.

The electronics power supply for each of the ACM's on one end shall be fed from separate redundant AC power supplies.

5.7.6 Field Supply Modules (FSM's)

Each Armature Control Module (ACM) shall control one motor Field Supply Module (FSM), for a total of two FSM's for each motor. The FSM's shall be Avtron ADDvantage 32 Field Modules (AFS), Siemens Simoreg 6RA70, or equal. The FSM's shall be 3-phase, 4-quadrant, and shall have a rated output of at least 60 A. No portion of the existing Ross Hill field supply SCR's or controls shall be reused.

The field supply isolation transformers shall be replaced.

Contractor shall supply FSM output contactors. Contractor's design shall utilize FSM output contactors such that the switching of FSM's will prevent the loss of propulsion or propulsion control, or a reduction in available propulsion power for more than 5 seconds.

AC power for the FSM's shall be fed from separate main switchboard circuit breakers, separate redundant transformers, and separate cabling. Main Propulsion Switchboard circuit breakers shall be either Square D Type FI or KI breakers, or equal, that shall have a minimum fault current rating of 100kA. Each circuit breaker shall be equipped with a padlock lockout bracket. Any removable covers shall accommodate the padlock device. The installation shall consist of a dead front panel to which the circuit breaker shall mount and extend thru pattern cut outs located on the dead front. Provisions shall be made on the dead front panel to provide terminal blocks located to make up all auxiliary circuit breaker connections.

5.7.7 Shaft Tachometers

The existing motor tachometers at the front of each motor shall be replaced with optical encoders. The encoders shall be Huebner-Giessen Type FG4RR, or equal, and shall have a metal optical disk with two independent and isolated sets of scanning electronics. Each encoder output shall provide a motor speed feedback signal to each of the ACM's. The encoder signal shall be used for shaft speed feedback and speed control.

Shaft speed signals for the Shaft RPM meters on the EOS and Pilothouse consoles shall be derived from separately supplied tachometers. The output from these encoders shall be converted to 4-20 mA signals for both the EOS and Pilothouse meters. This dedicated system, separate from any drive voltage or current feedback loop, shall meet USCG requirements.

5.7.8 Operator Panels

The existing Ross Hill Central Diagnostic Modules (CDM) on the SCR cubicle doors shall be replaced with 10.4" TFT flat operator panels. The operator panels shall be an Allen-Bradley PanelView 1000 Color Display with keypad, Siemens MP 270B 10" display with keypad, or other ABS Approved equal. Two operator panels shall be installed in the SCR cubicles at each end. The two Propulsion Control PLC's shall communicate with the operator panels on the SCR cubicle door. The existing CDM's on the EOS console shall be removed and replaced with two of the same operator panels used at the drives.

The operator panels shall, at a minimum, have the same functionality and display the same information as the existing Ross Hill CDM displays, unless otherwise specified. The operator stations shall display details of all propulsion system status and faults. This shall include system status information and fault messages currently displayed on the existing Ross Hill System Status Boards.

The operator panels shall have the ability to display all drive parameters, status, alarms, and voltage and current levels (AC and DC) that are part of the drive. Alpha-numeric displays at the drive cubicles shall be NEMA 12 and of rough duty industrial quality. LCD style displays, if used, shall have back lighting, have high contrast and a wide field of vision.

Drive cubicle displays shall be used to present information in a text or graphical nature that will aid the operating Engineer in the operation, maintenance and repair of the respective equipment. Self test diagnostics and diagnostic and troubleshooting aids built into the equipment shall use the displays to interface with the Engineer. Detailed information on the status, position, temperature, resistance, speed, operation or other functions that would aid the operating Engineer shall be capable of display in a format that is clear and concise. Transducers, sensors, switches and other components required for proper operation shall be provided for the remote monitoring required.

The PCS operator panels shall include a display of thyristor diagnostic information similar to thyristor diagnostic information available on the existing CDM modules. Shorted thyristors shall be detected and individually identified on the operator panel.

5.7.9 Propulsion Transformer High Temperature Alarms

Contractor shall install temperature alarm switches into each of the four propulsion transformers located on the shaft alley platforms. These alarm switches shall be installed in accordance with 46 CFR, specifically Subpart 111.33-11 & ABS (1996) 4/5D2.17.10.

5.8 Propulsion Motor

The MV ELWHA has one DC Propulsion Motor at each end of the vessel directly coupled to the propulsion shaft. There are a total of two (2) electrically independent propulsion motors on the vessel.

The existing propulsion motors shall be reused. The motors have been in service since 1967, and were rebuilt by Westinghouse in 1991. The rebuilt motors have a different design from the original motors. This new design does not require interpole equalizer windings. The armature is wound using a fully compensated winding design known as a "frog leg" winding. There is also only one field winding, whereas the original design had two field windings.

5.8.1 General Requirements

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5.8.2 Nameplate Data

Motor Nameplate Data.	ELWHA
Maker	Westinghouse
HP	6600 HP
Volt	850 V DC
Amps	6000 A
RPM	180 rpm
Temp Rise Cont.	70 deg. C
Instr. Book	20446
Motor No. 1 serial No.	7S-73P345
Motor No. 2 serial No.	8S-73P345

5.8.3 Thrust Bearing Pulling Limitation

Each motor's thrust bearing has been designed with six thrust pads in the pushing direction and three pads in the pulling direction. Furthermore, the pushing set of six have a leveling plate while the pulling set of three do not. As a result, the thrust bearing has a reduced thrust rating in the pulling direction. Motor ratings and thrust bearing limitations for different directions must be considered for all modes of operation. On MV Elwha, each motor's shaft power output shall be limited to 6600 HP at 180 RPM when pushing and 2500 HP when pulling.

5.8.4 Incorporation of Existing Motors and Thrust Bearings

The Contractor shall incorporate the existing propulsion motors and thrust bearings into the design of the new PCS. Existing sensors, auxiliary systems and equipment characteristics shall be assimilated into the Contractors' design, as called out in other sections of this specification, to provide continued functionality of existing systems.

The Contractor shall replicate the existing SCR drive current limits designed into the existing Ross Hill system. The existing system places a continuous current limit of 5500A in the SCR drive software/hardware. The existing system only allows for 6000A on a 1-minute overload basis. The primary use of the 6000A 1-minute overload period is to provide additional power for crash stops and other emergency maneuvering. Contractor shall program these limitations into software. Current limits shall have the means to be modified to higher values either as a result of information learned during sea trials or at a later date as a result of further modifications and improvements to the PCS. Current limitations shall only be modified from those specified here with the approval of the WSF Project Manager.

5.9 PROPULSION CONTROL AND INSTRUMENTATION SYSTEM

5.9.1 General Requirements

The PCS furnished by the contractor shall be a complete, integrated package consisting of all equipment, components, sensors, displays, controls, and other devices required to implement a fully functional propulsion system, including control and instrumentation from and to the propulsion diesel-generators. The system shall be digitally based with redundant PLC controls, including self-diagnostic and automatic changeover (hot backup) functions. All control and transfer functions shall be accomplished using redundant PLC controllers and redundant remote I/O modules, hereinafter called Remote I/O Stations (RIO).

The PCS shall fully comply with USCG requirements found in CFR46, specifically Subchapters F and J, and Subparts 61 and 62. But, the PCS shall diverge from the stated intent of 46 CFR 62.35-5(e)(3). Instead, the preset (as is) speed and direction of thrust shall default to zero speed in the event of a complete control system failure. Complete control system failure shall mean at least a two-point failure that leads to either complete power or communication loss in redundant systems. The system shall default to zero speed until the propulsion control system can be brought back online or local manual or alternate manual control is in operation. Failure must still activate alarms on the navigating bridge and in the machinery spaces in accordance with this subsection of CFR. If requested by the contractor, a copy of the USCG letter permitting this exemption can be supplied.

The system shall be of the open (expansion capable), distributed and modular type for the control, alarm and monitoring of ships systems. PLC systems shall be Allen-Bradley ControlLogix/ControlNet, Siemens S7-400H, or equal. Two PLC's on each ship end shall operate as a synchronized redundant pair, with only one PLC in control at one time. Each end's PLC's shall be installed either into the existing SCR cubicles or to adjoining enclosures. In either case, the status indicators available on the face of the PLC and associated modules shall be visible through polycarbonate windows installed in the panel covers to allow observation of LED status for problem analysis purposes.

The PCS shall be capable of modification of all system setpoints, graphics displays, and PLC programming by WSF personnel. All equipment necessary to perform this function shall be furnished to WSF by the Contractor as part of the scope of supply. Remote I/O shall be configured in a shared manner such that a failure of either PLC or of any single portion of the network connection shall allow each remote I/O station full and continuous operation by the other PLC or network. Specific remote I/O signals shall then be made redundant between different shared remote I/O stations. Non-redundant I/O signals will only be allowed where their failure does not result in loss of full and continuous operation of the propulsion system.

The PCS shall have the capability to distinguish between two groups of alarms, vital propulsion alarms and non-vital alarms in accordance with USCG regulations. Alarms considered "vital" shall be as defined by the USCG and ABS. "Important" sensors are those not considered vital, but the loss of which would hinder or make more difficult the monitoring and operation of the propulsion control system, even though it would not prevent

operation in a normal manner. All main engine parameters monitored on individual meters at the EOS console are considered as important, including the "kW" meter for main alternator.

All analog signals shall be 4-20ma where possible. The system shall be capable of broken wire or sensor failure detection for analog points, and shall give an appropriate alarm.

The Contractor shall provide any test kits or rigs, such as RTD or thermocouple simulators needed, to demonstrate the satisfactory operation of alarms. Simulators shall inject signals as close to the sensors as possible, not downstream of the transmission units. The ability to quickly access RTD or thermocouple sensors without the necessity of cutting cables or wires shall be incorporated.

As guidance for completing PCS measurement, control, and alarms, the Contractor shall use the preliminary PCS I/O List, 8204-669-099-22. This list is not intended to be complete and final. The list shall be supplemented by the Contractor with all necessary control points, monitoring points, and alarm points which are necessary to provide a safe, self diagnostic system and meet the requirements of this specification, applicable ABS Rules, and USCG Regulations. The Contractor shall be responsible for maintaining this list, showing current design status of all points, including spares I/O points. The final form of this list shall be grouped by RIO location.

PCS architecture shall consist of redundant control PLC's, redundant remotely located remote I/O (RIO), and operator control devices that are redundant at the signal level, which shall allow for normal propulsion control when one system fails. Separate 24VDC power sources shall be used to supply the redundant components. Provide at each control station independent propulsion control alarms when power to the console fails. RIO communication shall be provided by separate cables for each communications bus. The RIO communication bus shall be redundant, closed loop type. Failure of one segment of the communication bus or auto changeover will not interrupt communications. When specifying cable in the Contractor Bid Support Package, provide for spare conductor set within each communications cable, terminated with connectors. Cable shall be marine type USCG approved Low Smoke cable, when available, or other USCG approved cable to suit installation.

The base system shall comply with the minimum alarm requirements of the USCG for remotely controlled propulsion systems. Required vital propulsion alarms shall be displayed independent of the existing auxiliary Alarm & Monitoring System (AMS). The propulsion system shall be controlled from the propulsion control console located at the Engineers Operating Station (EOS), and both of the Pilothouse control panels. The EOS console shall be the master control station and shall allow the engineering watch stander remote control of the retrofitted drive cabinets and propulsion motors (existing) as described in this Section and other Sections of the Specification. Small propulsion control panels limited to an engine order telegraph, motor throttle handles, communications, and certain vital indications detailed below shall be provided on drop-in panels for each of the two (2) pilothouses.

The Contractor shall supply new Engineer Operating Station (EOS) propulsion control console drop-ins. Remote controls, throttle wheel, manual speed control levers, indicators,

graphic alarm displays, communications, control transfer buttons, EOT's and other devices necessary to allow the Engineering watch personnel full control and monitoring capabilities of the PCS shall be installed. At either the EOS console or propulsion switchboard, the operator shall have complete remote control of all functions necessary to stop main propulsion diesels, energize propulsion motor drives, control direction and speed of the propulsion motors, and receive and respond to EOT commands from either Pilothouse. A manual back-up propulsion motor speed control system shall include EOS lever throttles with potentiometers that are independent of the propulsion PLC control system and interface directly with the propulsion drives.

The EOS console shall include control of all auxiliary equipment required to operate and monitor the propulsion, PCS, as well as emergency shutdowns for engines and motors. The existing sound powered telephones and "Mackay" maneuvering intercom shall be reused. Other reused control components such as new operators for Engine Emergency Stops, Engine Room Call, Wrong Direction Lamps, and Emergency Signals, buttons, and lamps shall be interfaced with existing terminals, circuits, and cabling where possible. Any new terminals or wiring needed to maintain functionality shall be provided by contractor and included in their design. Any new cables required shall be the responsibility of the contractor to outline in their Contractor Bid Support (CBS) package. The final design and layout of all consoles shall be approved by WSF Vessel Design prior to construction.

The Contractor shall design and provide new EOS console drop-ins and new pilothouse drop-ins, for drop in installation by the contractor in the existing console framework.

The EOS console shall be equipped with a bi-directional control handwheel for combined control mode operation, as well as separate manual control potentiometer handles for direct emergency manual control of the drives. All necessary instrumentation and displays to allow control of motor speed and direction, and to allow monitoring selected propulsion plant operations shall be installed in the EOS console as described below, as well as means to communicate with the pilothouses.

The propulsion motors shall be controlled so that the "pushing" motor at the "stern" will drive the vessel forward while the "pulling" motor at the "bow" is driven in reverse to overcome propeller drag. For the purposes of this specification, "pushing" is defined as thrust causing the opposite end of the vessel to progress through the water and "pulling" is defined as thrust causing the same end of the vessel to progress through the water. To stop the vessel, the bow motor shall be "pushing" the vessel to develop primary stopping thrust while the stern motor shall be "pulling". The Pilothouse control throttles are identified as "bow" and "stern", the "bow" control for the motor at the same end of the vessel as the controlling pilothouse and the "stern" control for the motor at the opposite end of the vessel.

The propulsion motor control system shall consist of two (2) functionally separate control systems; the normal throttle control system, with Maneuvering and Transit modes of operation, and an emergency manual control system which provides direct manual control of the drives, bypassing the normal controls to the greatest extent practical.

The pilothouses shall be equipped with throttle levers only, whereas the Engineer's Operating Station shall have one handwheel for normal operation and two independent, manually

operated lever throttles for emergency manual control. The propulsion system shall be fully capable of continuous operation with control in either Pilothouse or at the EOS.

The control system shall be designed for safe, effective, and reliable control. The components used in the equipment of the control system shall be selected or manufactured for reliability, maintainability, availability and be suitable for the numerous operating cycles expected aboard short haul ferry service. Relays shall be of the sealed type wherever possible.

The propulsion control circuits shall be protected from spikes, harmonics, and other electrical noise generated by the drives and shall regulate power to all logic cards, electronics and CPUs. Transfer to standby or backup power sources shall not cause a malfunction, loss of control or CPU lockup. The interior of the EOS shall be complete with two (2) duplex receptacles and interior fluorescent lighting, activated with door mounted limit switches. A final list of meters to be mounted on the console shall be developed in conjunction with the WSF representative designated by the WSF Project Manager.

The contractor shall provide additional sensors, meters, indicator lights and displays at the EOS console as required to properly monitor and operate the propulsion plant, including during emergency conditions. Sensors for vital control functions shall be separate from sensors for alarm or monitoring functions. Indicator lights shall be provided for certain vital or important status displays, generator on-line, pilothouse call, and propulsion control failure. Meters shall be provided for important analog indications, including shaft tachometers, motor armature current, propulsion generator kW, and diesel auxiliary systems conditions.

EOS control and display surfaces (drop-ins) shall be stainless steel or brushed aluminum. Pilothouse control and display surfaces (drop-ins) shall be painted with a powder coated black surface to match the existing pilothouse consoles. All consoles shall be NEMA 12 at a minimum to prevent spilled liquids from entering the console interior.

All console arrangement guidance drawings are conceptual only. Final console design and layout are subject to change after design drawing review.

A standard three prong (U ground) 115 VAC power receptacle and internal fluorescent lighting shall be provided inside each individual section of each propulsion control console to support maintenance and trouble shooting. Power for receptacles and lighting shall be from ships final emergency power, cable provided by the shipyard to Contractor terminals. Internal lighting shall be activated by cabinet door switch.

5.9.2 Control System

Each pilothouse throttle lever control handle shall have a detented zero position at the center top and ten equally spaced positions on each side of zero, covering about 90° of travel in each direction. The red, illuminated handle position indication shall be visible from directly above the handle.

The normal propulsion controls at the EOS console shall consist of a single handwheel .The handwheel at the EOS console shall be located with "zero" position at top-dead-center, with ten graduated steps on either side of zero. Total handwheel movement should cover about 270° of travel.

When propulsion control is at the EOS handwheel, the control mode, known as Combined Mode, shall behave similarly to the Pilothouse Transit Mode. Movement of the handwheel toward the No.1 end of the vessel shall cause the No.1 end motor to pull, and the No.2 end motor to push. Movement of the handwheel toward the No.2 end of the vessel shall cause the No.2 end motor to pull, and the No.1 end motor to push. The pulling motor RPM shall have the same ratio to the pushing stern motor speed as that used in the Pilothouse Transit Mode. The handwheel pointer will always point in the direction the vessel will move as a result of the commands from the handwheel.

The transit mode and combined mode speed ratios shall be determined empirically during sea trials based on desired motor power levels and minimum vessel vibration. Typically in transit or combined mode the bow motor power is approximately 4%-6% of the stern motor power.

The handwheel will also have a second control mode known as Split Mode. The handwheel shall be placed in Split Mode by pressing down on the illuminated maintained Split Mode pushbutton on the EOS console. Movement of the handwheel shall allow each end to output power in an independent ratio equivalent to the handwheel position attained. In this mode, no ratio between ends will be applied.

Moving the handwheel towards the No. 1 end to the 5 position, for example, shall allow the No. 1 end to pull at approximately fifty percent of its pulling power limit whereas the No. 2 end will push at roughly fifty percent of its total power limit. The actual ratios of power output to handwheel position in Split Mode shall be determined at sea trials. Regardless, moving the handwheel to either position 10 on the handwheel shall allow the pulling end to achieve its full pulling power limit dependent only on power limit feedback signals from the generators.

Each pair of potentiometers in each of the pilothouse control handles or the handwheel shall be monitored by the Propulsion Control PLC's on the relevant end. The potentiometer with the higher absolute value shall be the one that is used by the PCS for speed reference. If the difference between the two potentiometer signals exceeds a predetermined threshold, a throttle fault shall be annunciated visually and audibly at that control station.

Whenever a speed, frequency, load or power limit is attained at either the pilothouses or the EOS, the PCS shall prevent the drives, motors or generators from exceeding the limits. Whenever the sum of the commanded throttle speeds for the two (2) ends of the vessel results in an overload to the propulsion generators, the PCS shall limit power supplied to the motors so that generator/engine ratings are not exceeded.

Emergency Manual Control shall consist of two lever throttles located on the EOS console, one for each end of the vessel. Each lever shall control a potentiometer for each drive half at each end of the vessel, thus two potentiometers for each throttle. The potentiometers shall be directly connected to a dedicated input port on each motor's drive controller, separate from the PLC speed reference signal input. This port shall be selected by the drive logic as the speed reference signal source whenever the Handwheel-Lever Mode Switch at the EOS console is in the Lever Mode position.

The Emergency Manual Control mode of operation shall allow direct control of the propulsion motor drives to set motor speed and direction. This shall be performed at the EOS and shall not use the normal automatic speed control circuits associated with the throttle handles. Propulsion Control PLC ramps, limits and ratios shall be bypassed. All metering and alarm functions shall be retained.

All control options are illustrated in the following table.

Table 3-7-1

Propulsion Control Options

Prop Ctrl Mode	**Normal**			**By-Pass**	**Emerg.Man**
Mode of Operation	Maneuvering	Transit	Combined	Combined	Split
PH Operator	Two Handles	One Handle	EOT	EOT	EOT
EOS Operator	N/A	N/A	EOT/Ctrl Handwheel	EOT/Ctrl Handwheel	EOT/ Emerg. Pots
Control System	PLC/Drive	PLC/Drive	PLC/Drive	PLC/Drive	Man/Drive
Control Characteristic	Independent each End. Remote ctrl with safety limits Gen/Dr/Mot.	Integrated both end ctrl. Remote ctrl with safety limits Gen/Dr/Mot.	Integrated both End ctrl. Local ctrl with safety limits Gen/Dr/Mot.	Integrated both end ctrl. Local ctrl with safety limits Gen/Dr/Mot.	Independent each End ctrl. Manual/local w/o safety limits Dr/Mot
Propulsion	End 1 or 2 or Both	End 1& 2	End 1& 2	End 1& 2	End 1or 2 or Both

5.9.3 Propulsion Control Logic

The propulsion system startup procedure shall be as follows:

- Propulsion AC bus is energized.
- SCR circuit breakers are closed.
- EOS Handwheel is set to zero position. The EOS cannot take control unless it is zeroed.
- Control Here pushbutton on the EOS console is pressed.
- Motor contactors are closed using the Motor On/Off switch. EOS Handwheel is now in control.
- Control may be transferred to the pilothouses.

The propulsion system shutdown procedure is as follows:

- Control transferred from pilothouse to EOS Handwheel.
- Motor contactors are opened using the Motor On/Off switch.
- SCR circuit breakers are opened.

At any time the PCS's for either end can be switched manually between Systems A and B using the DC Module Select switch. Normally, the switch will be in the auto position.

The permissives required to close the motor armature contactors on one end shall include:

- At least one SCR deionized water cooling system not faulted.
- At least one ACM not locked out.

A motor armature contactor shall open if any of the following conditions are present:

- Motor CO2 Shutdown is activated.
- Relevant SCR circuit breaker is open.
- Motor Lockout pushbutton at the SCR cubicle is pressed.
- Motor On/Off switch on the EOS console is in the Off position.

Reset pushbuttons on the EOS console and on the SCR cubicle shall be used to reset the ACM's in the event that one is faulted and locked out.

The Emergency Stop pushbuttons in the pilothouses shall cause the relevant shaft speed reference to go to zero instead of shutting down the drive. Control handle operation shall be restored when the Emergency Stop pushbutton is released. Pilothouse Emergency Stop signals shall be hardwired direct to the ACM's.

5.9.4 Motor Speed Control

Speed references received by the Propulsion Control PLC from the pilothouse control handles or the EOS handwheel shall be limited by speed ramp rates and maximum speed limits.

Speed ramp rates shall vary depending on the number of propulsion generators on line, full or half bridge power available, and the shaft speed. There shall be at least two speed-dependent ramp rates. Each ramp rate shall be individually adjustable.

Maximum shaft speed shall be limited depending on the number of generators on line and whether full or half bridge power is available. Each speed limit shall be individually adjustable but be password protected. Vessel SCE shall be provided the password and shall have the ability to change it as necessary.

Speed limits and ramp rates shall be individually optimized for all possible modes of operation. Ideally the ramp rates and speed limits are set so that the generator power or current limiting functions do not normally become active except during turns or crash stops.

Internal speed limits and ramp rates shall also be utilized for the hardwired Emergency lever throttle mode. Such speed limits and ramp rates shall be internal to each ACM. As a result, such speed control in Emergency lever throttle mode shall be a reduced set from that which the PCS PLC's utilize.

The functionality of the Motor Maximum Speed and the Motor Maximum Pulling Voltage potentiometers shall not be reproduced in the new PCS.

Both propulsion motors shall normally be speed regulated utilizing the shaft encoder as the speed feedback signal in closed-loop control. In the event that the tachometer fails the drives shall continue to operate using armature voltage feedback for speed regulation.

5.9.5 Control Station Transfer

The Control Transfer system shall fully comply with USCG requirements found in 46 CFR. But, the Control Transfer system shall diverge from the stated intent of the final sentence of ABS (1986) Section 41.19.4 referenced by 46 CFR 62.35-5(d). This section of ABS Rules requires no significant change in propelling thrust when transferring control from one station to another. This is contrary to WSF practice, by which each station is independent and the machinery shall respond to the control settings of the receiving station, irrespective of the sending station's control settings. If requested by the contractor, a copy of the USCG letter permitting past exemptions from this requirement can be supplied.

Only one (1) control station at a time shall have control of the propulsion motors. The EOS shall at all times be able to override either of the Pilothouse control stations by taking control back to the EOS via the normal control transfer function or the emergency manual override switch. Transfer of control from EOS to Pilothouse or Pilothouse to Pilothouse shall be possible only after initiation by the station in control and acknowledgment by the receiving

station. It is the intent of WSF that control transfer between stations shall require the actions of two (2) operators, one (1) in each location, so that control cannot be transferred to an unmanned station.

There are three primary control stations: the EOS handwheel, Pilothouse 1, and Pilothouse 2. Only one of the three control stations shall have propulsion speed control at one time. The determination of which station is in control, and the transfer of control from EOS to pilothouse or between the pilothouses shall be performed by the Control Transfer PLC.

The existing Control Transfer PLC's shall be replaced by a single Allen-Bradley SLC-500 PLC, a Siemens S7-300 PLC, or equal.

Control station status shall be sent from the Control Transfer PLC to each of the Propulsion Control PLC's where the selection of the correct speed reference shall take place. It shall not be possible for the two PCS's at each end to have different primary control stations in control at the same time.

With the exception of the EOS Manual Override switch, transfer of control between stations shall only be possible when the sending and receiving control stations have all throttle levers or EOS handwheel in their "zero" position. If the throttle control system does not detect a zero throttle position at the sending and receiving station, then no transfer may take place. Each control station shall have associated LED status indicators to indicate when the throttle lever is in the zero detent position

The determination of which station is in control, and the transfer of control between the pilothouses or between one pilothouse and the EOS Handwheel, shall be performed by the Control Transfer PLC. Control station status shall be sent from the Control Transfer PLC to each of the Propulsion Control PLC's where the selection of the correct speed reference shall take place

The procedure for transferring control from the EOS Handwheel to Pilothouse 1 shall be as follows:

- With the EOS in control, both the Transfer Control Here illuminated push button at the EOS and the EOS in Control light at both pilothouses will be continuously lit.
- The EOS Handwheel is put in the zero position.
- The Transfer Control to Pilothouse 1 pushbutton on the EOS console is pressed and held.
- The EOS in Control light in both pilothouses flashes.
- If the control handles in Pilothouse 1 are zeroed, the Control Acknowledge light in Pilothouse 1 flashes.
- The Control Acknowledge pushbutton in Pilothouse 1 is pressed and control passes to Pilothouse 1.
- The Control Here light and the Control Transfer illuminated pushbutton in Pilothouse 1, the Pilothouse 1 in Control light on the EOS console, and the Pilothouse 1 in Control light in Pilothouse 2 illuminate. Both the Transfer Control Here illuminated push button at the EOS and the EOS in Control light at both pilothouses will be extinguished.

The same procedure shall apply to the transfer of control from the EOS Handwheel to Pilothouse 2 with references to “Pilothouse 1” and “Pilothouse 2” interchanged.

The procedure for transferring control from Pilothouse 1 to Pilothouse 2 shall be as follows:

- Pilothouse 1 control handles are put in zero position.
- Control Transfer illuminated push button at Pilothouse 1 is lit indicating that transfer may be initiated.
- Control Transfer illuminated push button at Pilothouse 1 is pressed and held.
- Pilothouse 2 in Control light at Pilothouse 2 flashes. Pilothouse 1 in Control light at Pilothouse 1 flashes.
- If the control handles in Pilothouse 2 are zeroed, the Control Acknowledge light in Pilothouse 2 flashes.
- The Control Acknowledge pushbutton in Pilothouse 2 is pressed and control passes to Pilothouse 2.
- The Control Here light and the Control Transfer illuminated pushbutton in Pilothouse 2, the Pilothouse 2 in Control light on the EOS console, and the Pilothouse 2 in Control light in Pilothouse 1 illuminate. The Pilothouse 1 in Control light at the EOS console and Pilothouse 2 and the Control Here light at pilothouse 1 will all be extinguished.

The same procedure shall apply to the transfer of control from Pilothouse 2 to Pilothouse 1 with references to “Pilothouse 1” and “Pilothouse 2” interchanged.

The procedure for transferring control from Pilothouse 2 to the EOS shall be as follows:

- Pilothouse 2 control handles are put in zero position.
- Control Transfer illuminated push button at Pilothouse 2 is lit indicating that transfer may be initiated.
- The EOS Transfer Control Here illuminated pushbutton is pressed and then begins to flash. Pilothouse 2 in Control lights at both pilothouses and the EOS flash.
- Provided the control handles in Pilothouse 2 are still zeroed, the Control Acknowledge light in Pilothouse 2 flashes.
- The Control Acknowledge pushbutton in Pilothouse 2 is pressed and control passes to the EOS.
- The Transfer Control Here light at the EOS and the EOS in Control light at both pilothouses are illuminated. The Pilothouse 2 in Control light at the EOS console and Pilothouse 1 and the Control Here light at pilothouse 2 will all be extinguished.

The same procedure shall apply to the transfer of control from Pilothouse 1 to the EOS with references to “Pilothouse 1” and “Pilothouse 2” interchanged.

Control shall not transfer if the control handles in either the transferring or receiving station are moved away from zero during this procedure. If this occurs, the flashing lights for the current control station will return to continuous illumination. Similarly, if the initiating station releases its control transfer button prior to the receiving station accepting control, the

flashing lights for the current control station will return to continuous illumination and the initiating station will be placed back in control.

The EOS lever throttles will provide a hardwired, completely separate, alternate control method direct to each ACM. Hardwired contacts off the EOS handwheel-lever mode switch direct to the ACM's will enable the lever throttles. A lever mode light will provide feedback that the ACM has been placed in hardwired lever mode. The handwheel-lever mode switch at the EOS console shall also provide input contacts to the PCS and control transfer PLC's to notify of the transfer to alternate control.

Control shall be transferred from the EOS Handwheel to the EOS Lever throttles by turning the EOS handwheel-lever mode switch to the lever mode position. Control shall be transferred from the EOS control handles back to the EOS Handwheel by first returning the handwheel-lever mode switch to the handwheel position, and then pressing the Control Here pushbutton at the EOS console.

At any time, it shall be possible to bypass the Control Transfer PLC and take control at the EOS directly using the Manual Control Override switch on the EOS console. The Manual Override light will flash until the handwheel throttle is brought to the zero position at which time it will come on continuously. Manual Override shall be indicated at each pilothouse with the Transfer Bypass lights and an audible indication.

Failure of the Control Transfer PLC shall be annunciated at the EOS console and at both pilothouses with both visual and audible indication.

The Control Transfer System design shall meet all requirements of CFR Title 46, including Subsection 62, as applicable.

5.9.6 Control Station Equipment

The PCS equipment shall include all features and alarms required for USCG certification of remotely controlled systems under CFR Title 46, Parts 61 and 62. It shall also be designed, constructed and tested to ABS rules for classification as ACC.

The new pilothouse drop-in panels shall be used to mount all devices necessary for the pilothouses to control propulsion motor speed and direction, monitor propulsion plant status, shaft speed and rotation, and to send commands and receive responses (EOT). Stainless steel or aluminum back plates with sufficient terminal boards for making all propulsion control component connections shall also be provided for each console. The drop-in panels shall fit the existing Pilothouse consoles. Their design shall be approved by WSF Vessel Design prior to construction. The existing Engine Order Telegraph (EOT) is presently connected as an integral part of the existing PCS. The Contractor shall modify the existing EOT's as necessary to meet all requirements of these specifications and USCG requirements.

The Contractor shall provide all components specified at the end of this Section for installation in the pilothouse consoles. All material necessary to install the complete system, including any special tools, connectors, templates, terminal blocks, cable harnesses, and procedures required for installation, shall be provided. Existing components may be reused

if suitable for the contractor's new control system, identified to WSF during the design process, and approved by WSF prior to manufacturing. However, all similar components of the final installation (pilot lights, switches, push buttons) shall be the same brand and size.

The Contractor shall modify standard EOT systems to meet WSF special requirements for a double ended ferry. EOT systems shall be supplemented with WRONG DIRECTION and EOT FAILURE alarms and indications. Both audio and visual signals shall be alarmed provided at each control station. The WRONG DIRECTION alarm shall be activated when the EOS Handwheel is moved to the wrong side of the "zero" position of the Handwheel when compared to the command direction from the PH EOT. EOT FAILURE shall alarm when either the transmitting or receiving circuits lose power. EOT alarms shall be independent of the EOT power supplies.

PCS throttle assemblies shall be a WSF approved assembly, manufactured by PRIME MOVER CONTROLS, or WSF approved equal. The existing pilothouse control handles shall be replaced with PMC Type 5800 MCH-E control heads. The existing EOS Lever Mode control handles shall be replaced with PMC Type 5800 MCH-E control heads. The existing handwheel shall be replaced with a PMC Type 5061 handwheel.

Each pilothouse control handle shall have two potentiometers. Each potentiometer shall be redundantly connected to the PCS at one end. The handwheel shall have four potentiometers, each pair redundantly connected to the PCS at each end. Finally, the EOS Lever Mode control handles shall have two potentiometers, each redundantly hardwired to each ACM at one end.

Each pilothouse shall have two redundant potentiometer power supplies fed from separate 24VDC sources. Each power supply shall feed one potentiometer in each of the two pilothouse control handles and each of the potentiometers in each handwheel pair. The EOS lever mode throttles shall be supplied from separate redundant 24VDC supplies from the pilothouse throttles or EOS handwheel.

The throttle levers shall be of substantial construction with handles of sufficient length to provide tactile feedback of lever position. The levers shall also provide tactile resistance to movement similar to a pneumatic or cable throttle lever to provide "positive" feedback when making throttle command changes.

Throttle travel shall be about 80° each way from center. Handwheel travel shall be about 135° both sides of center. The throttle or handwheel potentiometers shall be center-tapped and adjustable such that they have an electrical means for zero adjustment to align the device electrical zero with the control lever and its zero detent. Adjustable mechanical limit switches shall be employed in the control head if required for reliability considerations. All adjustment provisions shall be multi-turn precision "trim pots" with locking provisions to prevent changes in adjustment due to vibration. Trim pot locks shall be friction collars or locking levers. Locking nuts are not acceptable. If digital devices are used, they shall include a means of locking settings or shall inherently maintain the last setting.

Each throttle lever or handwheel assembly shall have a position scale with zero center and 10 numbered, uniformly spaced marks on each side of zero. The Pilothouse assemblies shall

have internal, red, dimmable illumination with access to the lamps above the mounting plate without disassembling or removing the unit. The illuminated scales shall be visible from directly overhead.

Each pilothouse console shall be supplemented with "OTHER PILOTHOUSE CALL" blue lighted push button. Normally this push button shall be constantly back lighted with dimmer like other indication lights. When pressed in one pilothouse console other pilothouse bell and light shall activate with full brightness.

Indicator lights shall be low profile mounted and shall have colored lenses to convey the desired information. The color shall be integral with the lens and not externally applied. Lamps shall be a standard size, LED type, with wedge style base, or bayonet base. Standardization of lamp types used throughout the system shall be as consistent as practical to reduce spare parts stock. Any indicating lights, pilot lights, and alarm lights that cannot be provided with LED's shall use two incandescent bulbs per indication. Loss of one bulb shall not prevent the other bulb(s) from operating. In any case, all lamps shall be on lamp test circuits.

The various bells, buzzers, gongs and other audible devices used to alert personnel at the various control stations shall each be distinctive and unique in tone, pitch, timber and resonance to aid in determining the significance of any alarm or alert through audible devices. When electronic signaling devices are used, they shall have modulated tones and be audible above ambient noise levels for the location. All audible devices shall be subject to verification and acceptance by the WSF Inspector after installation.

Space for the mounting of additional terminal boards shall be provided in the base of the console.

All instrumentation systems shall be 24 VDC power derived from dual, dedicated low maintenance 24 VDC battery source.

5.9.7 Propulsion Status and Fault Indications

Any reduction in availability of normal propulsion control or propulsion power shall be annunciated visually and audibly in the pilothouses and the EOS. This shall include but is not limited to:

- Loss of one armature converter branch.
- Loss of one propulsion motor.
- Two or one generator on line.
- Control Transfer PLC failure.
- Control handle or handwheel potentiometer fault.

5.9.8 Maneuvering Intercom Circuit "2MC"

The EOS Console shall include a flush mounted speaker, a jack, a mating plug and foot switch dedicated for hands-off operation of the existing Mackay Model BTBC-3 intercom system. Locate the jack at a WSF designated location. At the EOS console, use the existing talkback speaker and connect all maneuvering intercom equipment to a separate terminal board.

Information on the BTBC-3 can be obtained from the WSF Project Manager.

5.9.9 Data Loggers

A data logger feature shall be provided for monitoring the PCS PLC's and the ACM's. It shall be an event recorder saving and presenting information in a graphical and tabular format to assist in PCS performance analysis and problem tracing. Each data logger shall be a dedicated PC configured with an IBA Process Data Acquisition (PDA) system or equivalent, and shall receive data digitally from the PLC and the ACM through either a Profibus or Ethernet connection

Each data logger shall be capable of continuously monitoring at least 256 digital signals and 256 analog signals from each Propulsion Control PLC at a sample time less than the cycle time of the PLC program (typically 30 msec), and to store this data for at least 30 days.

The Data Logger shall record various channels monitoring propulsion control and protection to aid WSF personnel in the determination of the sequence of events leading to a fault or unanticipated system response. WSF will work with the Contractor to develop a comprehensive list of data logger channels to be monitored. Many of the channels may be the same points monitored for normal alarm and monitoring purposes.

The Data Logger shall have a removable data storage feature. The data logging system shall include off-line analysis software so that data files may be analyzed at a remote location with another PC. The datalogging system shall use the Windows XP Pro operating system. Presentation graphics shall be developed in conjunction with WSF Project Manager.

The PLC signals to be monitored by the data logger shall include, as a minimum, all input and output signals, as well as all significant diagnostic system data. It is desirable to also monitor any software signals that would be useful in troubleshooting propulsion faults. The ACM signals to be monitored by the data logger shall include, as a minimum, the following signals:

- Armature current reference
- Armature current feedback
- Armature firing angles
- Field current reference
- Field current feedback
- Armature voltage feedback
- Motor speed
- Module status bits
- Module fault bits

- It shall not be possible to send data from the data loggers to the PLC or ACM's, or to affect the operation of the PCS in any way with the data loggers. This includes any failure of the PC or of the communication hardware.

5.9.10 VDR Interface

The PCS's shall include digital and analog signal interfaces to the vessel's Voyage Data Recorder (VDR). The signals used by the VDR are:

- Shaft rpm End 1
- Shaft rpm End 2
- Shaft speed command End 1
- Shaft speed command End 2
- EOS in control
- Pilothouse 1 in control
- Pilothouse 2 in control
- Propulsion System Failure End 1
- Propulsion System Failure End 2
- Propulsion Abnormal End 1
- Propulsion Abnormal End 2
- Control System Failure
- EOT 1 and EOT 2 status

5.10 VITAL SYSTEMS POWER SUPPLY

5.10.1 Propulsion Plant Systems Power Supply 24 VDC

The Contractor shall design systems for use of a redundant 24VDC Power Supply and Distribution System. Two battery banks, two battery chargers and two disconnect switches shall be located in two different locations on the lower car deck supplied and installed by the shipyard. Two independent, cross-connected 24VDC distribution panels shall be located in the EOS, supplied and installed by the shipyard, providing dual power sources to each subsystem of the PCS and supporting other vital systems.

Redundant 24VDC feeds to each major PCS component shall be monitored to alarm on loss of either feed by contractor. The existing 24 VDC battery power supply for the switchboard shall be removed by contractor and not replaced. The power supplies shall be floating with respect to ground. There shall be a ground fault monitoring system for monitoring both positive and negative ground faults of all parts of the 24VDC distribution system, supplied and installed by the shipyard.

The contractor shall identify any portions of their system that will require the introduction of DC-DC converters and/or the introduction of any grounds on the system. Contractor shall be responsible for installing additional ground detection devices downstream of any DC-DC converters installed. Any points requiring the introduction of a ground shall be identified to and be approved by the WSF Project Manager during the design phase.

A Propulsion Control 24VDC power supply system shall be designed by the Contractor for the power requirements of the various control, alarm, monitoring, communications and display functions required by this Specification, USCG and ABS.

The 24VDC power supplies shall be used for EOS and Pilothouse control console power, governor controls, instrument alarms, and any other low voltage based control, monitoring and safety functions of the propulsion plant. Any 120VAC PCS equipment shall use redundant UPS's separated between redundant systems and provided by contractor. The redundant components of the PCS shall receive power from alternate halves of the 24VDC battery system, such that upon loss of one battery power source, the PCS via the remaining 24VDC power source shall allow full normal operation.

The Contractor shall determine the actual required PCS 24VDC load required by conducting a 24VDC load analysis and obtain approval of the calculation by WSF Vessel Design.

Each battery power supply shall be equipped with an independent distribution panel, located in the EOS. Feeders to the Propulsion Control sub-systems and other vital systems shall be divided between the distribution panels to provide the most reliable power supply arrangement. It shall be possible to manually cross connect distribution buses to one battery and power supply with the other battery and power supply isolated.

The Contractor's electronic equipment shall be capable of using the nominal 24 VDC supplied from the battery source directly, or shall have internal filters, converters, or power

regulators to modify the battery supply to the extent necessary for proper operation of the contractor equipment.

The Contractor shall analyze failure modes for the 24VDC power supply system. Independence of the PCS from other systems will be an important subject of review during design review and drawing approval.

6.0 RELIABILITY/AVAILABILITY

6.1 Failure Modes and Effects

The contractor shall prepare a Qualitative Failure Analysis (QFA), a Failure Modes and Effects Analysis (FMEA), and a Design Verification Test Memorandum (DVTM) as required by the USCG in 46 CFR, Subpart 62.20-3(b) and Subpart 61.40, respectively, by ABS Rules for the Building and Classing of Steel Vessels, Part 4, and by these Specifications. The Contractor shall submit these documents through the WSF Project Manager for review and approval, prior to submittal by the Contractor to any Authoritative Agency. It shall be the Contractor's responsibility to obtain required Authoritative Agency approvals. The Contractor shall be the lead in this work, obtaining needed information from WSF, to achieve seamless and coordinated documents integrating both Contractor provided and/or modified systems and equipment with WSF responsible items.

The QFA/FMEA is intended to assist in evaluating the safety and reliability of the system design and as a training aid. The Contractor shall submit to the WSF Project Manager, a copy of the QFA, FMEA and DVTM for review and approval, in order to verify design configuration. These documents shall contain a level of detail necessary to demonstrate compliance with the requirements of ABS, the USCG and these Specifications and shall follow standard qualitative analysis procedures. Assumptions, operating conditions and failures considered, cause and effect relationships, how failures are detected by the crew, alternatives available to the crew, and necessary design verification tests should be included. The QFA, FMEA, and DVTM shall be used extensively in contractor conducted crew training after delivery of the vessels. Accordingly, they should be prepared in a logical, step-by-step manner that progresses in an orderly fashion.

A Periodic Safety Test Procedure (PSTP) including a list of test instruments, shall be developed by the Contractor and submitted for approval by the WSF Project Manager. The approved Perodic Safety Test Procedure shall become a document for submittal to Authoritative Agencies for approval, and shall be included in the final operating manual.

The PSTP shall be used during annual USCG inspections to demonstrate that vital systems and safety features continue to operate in a safe, reliable manner. In this regard, components used and the sequence in which the test is conducted shall be as efficient as possible. The intent is to have a document that does not require multiple trips to the same compartment and one that effectively exercises the sensors to demonstrate alarm conditions.

The PCS at each end of the vessel shall be fully redundant. No single component or circuit failure shall cause the loss of propulsion or propulsion control, or a reduction in available propulsion power for more than 5 seconds. The only exceptions are for failures in the armature power circuit, armature firing pulse circuit between a thyristor and a switchover module, a drive isolation or phase shifting transformer, failure of a main propulsion diesel/generator, or mechanical failure of a propulsion motor. A failure in an active PCS PLC, active ACM, or active FSM shall cause a switchover to the redundant PCS.

The failure of an armature thyristor, armature thyristor firing circuit downstream of an ACM switchover module, or armature DC contactor shall result in at most the loss of 50% of available propulsion power at one end of the vessel.

The PCS on one end of the vessel shall be independent and isolated from the PCS on the other end of the vessel except for any data required to coordinate bow speed reference or power plant limiters. The amount of data exchanged between the two systems shall be kept to a minimum. In the event that communication between the propulsion systems on opposite ends fails, there shall be no loss of available propulsion power.

The external control system at each control station shall have the additional requirement that loss of any single control component (throttle handle potentiometers, control transfer push buttons, drive control push buttons at EOS Console, propulsion control PLC and associated remote data collection units, and other similar components associated with propulsion control) shall cause no loss of normal propulsion control capability. The Emergency Lever Throttle controls do not satisfy this requirement.

The control PLC's and associated control signal inputs and outputs shall have 100% redundancy and be self monitoring, placing the standby logic unit on-line automatically on loss of control function of the active unit. The propulsion control PLC's shall operate in a Master/Slave mode, also called Hot Standby mode. On loss of a Master or Primary PLC, a Slave or Secondary PLC shall take over all control functions in a seamless and automatic manner, with no action required by the operator. Time for the backup system changeover shall be no greater than 0.5 second.

Redundancy of operator control signal inputs shall require only the signal be redundant, and not necessarily the actuator. For instance, there should be only one on/off switch on the EOS Console for Motor #1, but it should have at least two contacts, with one contact each going to alternate halves of the propulsion control PLC system.

6.2 System Availability

The propulsion system shall be designed and installed to provide a high system availability as hereinafter defined and described.

The system design shall incorporate features that will produce high system availability, including appropriate use of redundancy, and other features that provide for rapid detection, identification and correction of faults; for example, self-test diagnostics and modularity. Availability is different than reliability. A component may be very reliable, but if the eventual failure of the component causes loss of propulsion, it results in poor availability.

For the purposes of evaluating the availability of the power and control system, the vessel shall be assumed to operate 365 days per year. Availability shall be determined based on 8030 operational hours per year. These 8030 operational hours are comprised of 22 hours per operating day availability, with two (2) hours of tie-up. Repairs and routine preventive maintenance which can be deferred until, and accomplished during night tie-up periods, do not affect system availability.

Normal practice for operational periods will be for three (3) propulsion diesel generator sets to be running and on line. Normal operational practice for night tie-up will be for all propulsion diesel generator sets to be shut down with ship service power provided from the shore power connection or from the existing auxiliary Inport Diesel Generator.

Exclusive of existing installed machinery, the system is considered available if all normal control functions are in an operable state and the power system can deliver 100% of the rated ship's propulsion power, including 100% of the average ship service power, with all propulsion motors available. The normal control functions are considered to be in an operable state when the primary or standby means of providing these functions is operable. The Emergency Manual Backup control shall not be used in meeting this requirement.

For the purposes of the assessment of availability, the contractor's entire scope of supply shall be considered. To be considered to be in an available state, the power and control system must be capable of delivering and using the specified ship service and propulsion power and must be capable of responding properly to any fault in the power delivered to the system by the generators and/or any fault from the main propulsion motors and their associated static converters and transformers.

6.3 Accessibility

Where devices are parts of sub circuits assembled in physically identical modular units for easy mounting on, and removal from, the cabinet or console, suitable means shall be provided to facilitate correct identification and replacement of modules. The Contractor shall obtain WSF review and approval of the Contractor's component identification system.

Cabinets and other enclosures shall be front access only, wherever possible. Where rear access is allowed or required, components that are removable only from the rear shall be removable in the space allotted between the rear of the cabinet and the adjacent bulkhead or equipment, in accordance with 46 CFR, IEEE-45 and ABS. Components removable from the front of the cabinet shall require no more than three (3) feet free clearance from the front of the cabinet for removal. The propulsion switchboard may be allowed four (4) feet clearance if this does not present additional interferences. The Contractor shall provide adequate maintenance access for system components commensurate with their installation location.

6.4 Noise

The Engineer's Operating Station (EOS) and the Engineers Day Room (EDR) shall be considered an acoustic enclosure and an acoustically sensitive area, respectively. Sound attenuation within these spaces shall not be compromised. The Contractor shall be responsible for locating and correcting unsatisfactory noise conditions arising during tests or trials, or subsequently during the warranty period that can be directly attributed to the design, construction, or workmanship of those elements of the construction and installation accomplished by the Contractor.

6.5 Inspection

Approval by WSF, USCG, and other Authoritative Agencies as required by law shall be provided.

No Contractor equipment shall be manufactured until Contractor engineering calculations, design drawings, system schematics and equipment construction drawings have been reviewed and approved by the WSF Project Manager. Upon completion of manufacture of major components and some systems, WSF inspection and participation in factory design verification tests in Contractor facilities shall be required.

Testing of first units shall allow for attendance by WSF representatives, designated by the WSF Project Manager.

The Contractor is responsible for all fees resulting from Authoritative Agency inspection and/or certification.

6.6 Material

Unless otherwise specified, all equipment and material provided shall be new, suitable for marine use, and shall meet the requirements of all cognizant Authoritative Agencies for the intended service. Where a sheet steel gauge is specified it shall be USS for plain steel and USSG for galvanized material.

7.0 ADMINISTRATION, PLANS AND SCHEDULES

7.1 General

The Contractor shall provide all planning, scheduling, and other items in this Section to accomplish the work outlined in all Parts and Sections of this Specification.

7.2 Quality Assurance and Quality Control Plan

The Contractor shall establish and maintain a Quality Assurance and Quality Control Program (QA/QC) which specifically addresses the Work associated with this Contract. A QA/QC Plan documenting this program shall be submitted to the WSF Project Manager for approval.

The QA/QC Plan shall include or accomplish the following:

1. Describe the Quality Assurance organization, identify key personnel duties. Assign personnel by name and provide contact information.

2. Delineate the procedures established for:

   (i) controlling engineering and drawing development and adherence to invoked drawing standards;

   (ii) design verification;

3. Describe the organization and procedures for inspecting and checking work in progress for conformity to design, specification, drawings, and schedules.

4. Describe procedures for inspecting and checking work for completeness and pre-testing before the final tests required by this Specification.

7.3 Master Schedule

The Contractor shall provide a master schedule (Master System Manufacturing Schedule - MSMS).

Within twenty (20) calendar days after Contract execution, submit to the WSF Project Manager for approval an MSMS showing the order in which the Contractor proposes to carry out the work within the Contract time.

The MSMS shall be prepared using the Critical Path Method displayed in Gantt Chart format. The schedule shall show the proposed start and completion dates for planning and design development, system manufacturing, fabrication, assembly of principal components, assemblies, sub-assemblies, systems and testing, which comprise the scope of production work.

The work elements of the MSMS shall be used to construct the progress payment weighted factors.

The MSMS shall include, but not be limited to, system engineering and design, Authoritative Agency approvals, system manufacturing, factory testing, and all other milestones, including those required below and other events which may have a significant bearing on the delivery of the PCS.

Milestones represent critical measures of Contract work progress. The MSMS milestones shall include, but not be limited to, the milestones listed in Exhibit 3 of Volume 1 of this specification.

8.0 DRAWINGS, MANUALS AND SOFTWARE

8.1 General Requirements

It is the intent of WSF to eventually perform all maintenance on equipment provided under the Specification. Therefore, the Contractor shall prepare and deliver to WSF all technical manuals, parts manuals, training books, operational manuals, equipment service manuals, drawings, computer software, and other documentation required to operate, maintain, service and repair all equipment and components associated with the PCS, excluding diesels/generators and propulsion motors, but including all modifications to these items done as part of this control system replacement, as well as all unpacking and assembly instructions for all equipment shipped loose.

For each vessel receiving a new PCS under this Specification, the Contractor shall prepare or obtain, collate, bind, and reproduce as required, manuals, books and available software for all machinery, equipment and systems provided by the Contractor, whether manufactured by the contractor or not, in accordance with this Section. Manuals shall be provided that cover the methodology, use, modification and upgrading of the software used in the PCS. The manuals shall explain the concepts behind the implementation of the programs, all details on the use of the software including accessing functions, data, various screens and control modes, various levels of command control, modifying displays, set points and adjustable program parameters, and the procedure to obtain and install updates from the manufacturer.

Flow charts and annotated source code for all custom software associated with the PCS shall be provided in printed form and in text file form on magnetic media compatible with IBM PS/2 computers and DOS/Windows operating systems. A detailed description of the development system is to be included. A complete list of compilers, editors and other software used in program development shall also be included as well as details of any system emulation including a discussion of simulation methods. Any programming tools, including licenses, required to parameterize, modify, install, or upgrade programs in Contractor-supplied programmable devices shall be provided.

The manuals and books shall include assembly plans, sections, schematics, wiring diagrams, flow charts or specification sheets, as required, and line art as necessary to properly identify the various parts of the assembly, and careful documentation of periodic maintenance requirements. Schematics shall be provided for all circuits and circuit boards and shall show all interconnections, test points, and include signal tracing information. Any Ross Hill electrical drawing modified in whole or in part shall be replaced in full by the contractor's new drawing set. Only a Ross Hill electrical drawing left unaffected by contractor's work but to be reused shall not require replacement by the contractor's drawing set. The parts lists shall be keyed to the plans and line art to provide identification of the various parts. The manuals and books shall indicate the dimensions, weight, capacity and design conditions for the equipment.

All drawings, plans and schematics developed shall be CAD generated and delivered using AutoCAD® 2000i/2004/2005/2006.

Instruction books shall contain information at least equivalent to that available to mechanics at an authorized overhaul facility of the manufacturer of the machinery or equipment covered. Omission of information due to reasons such as "not normally furnished", "proprietary" or "factory only" will not be acceptable.

One (1) draft copy of each manual and book shall be submitted to the WSF Project Manager for review and approval not later than ninety (90) days prior to scheduled ship redelivery from the installing shipyard.

After incorporation of all material required by the WSF review, the contractor shall deliver five (5) sets of the finished product, per ship. Final editions shall be bound in substantial loose leaf 3-ring binders suitably marked on the front cover and spine as to content. Final editions shall be delivered prior to the scheduled Sea Trials date for the installing shipyard. Instruction books or manuals prepared by the Contractor using computer word processing equipment shall be delivered both in final paper form and identically on magnetic media disks, Windows™ compatible, in the format of MICROSOFT® Word™, Word for Windows™, or convertible equal delivered prior to Redelivery of the vessel.

The manual shall be updated to include changes and revisions to the system that may result from trials and testing. The update may consist of complete sections of the manual to which changes have occurred for insertion by WSF personnel into the original manual, or may be a complete new set of manuals (5 each) with all changes incorporated. The revised manuals shall be delivered to the WSF Project Manager no later than sixty (60) days after shipyard redelivery of each vessel to WSF.

The manual shall be updated to include any changes to the information contained within the manual that may occur due to manufacturer revision of parts numbers, instructions, component design, technical data, upgrades and improvements, or any other changes associated with the propulsion system that may occur for a period of six (6) years following final acceptance of the PCS by WSF for the MV Elwha. Each final manual delivered shall be placed on the manufacturer's service manual update list. Service updates and notices shall be provided for a minimum period of six (6) years after final acceptance of the MV Elwha system.

8.2 Final As-Built Drawings

All drawings shall be updated to " FINAL AS-BUILT " drawings at the time of final acceptance of the system.

All FINAL AS-BUILT drawings shall be validated by ship check. These submittals shall be clearly marked FINAL AS-BUILT and include the name of the MV Elwha. The drawings shall be complete, including all revisions necessary to reflect the configuration of the system on the day of its Final Acceptance as defined by the Contract. The wiring diagrams shall

identify all cables and wiring, including wiring floaters, as described in Section 5.3.2.4 of the Specification.

A complete corrected index of validated FINAL AS-BUILT drawings shall be prepared for inclusion in the final submission.

Within thirty (30) days after final acceptance of the PCS system by WSF, provide three (3) hardcopy prints, and three (3) identical CD-ROM disks containing all validated FINAL AS-BUILT drawings, engineering calculations, sketches, and any other documentation for the PCS system to the WSF Project Manager. Each drawing shall accurately reflect the validated FINAL AS-BUILT condition of the system.

Final acceptance as defined in the Contract will not be executed until delivery of the validated FINAL AS-BUILT drawings.

8.3 Historic Drawings

A limited number of Vendor drawings and, shipyard installation drawings, used in the construction and renovation of the MV ELWHA, are available for examination in the offices of the WSF Technical Library, 2901 Third Avenue, Suite 330, Seattle, during normal working hours Monday through Friday. The drawings are offered for information only and WSF makes no representation as to their reliability, accuracy or currency. The Contractor shall be wholly responsible for verifying conditions as they exist on the vessel at the present time. Inspection of such drawings may be arranged by calling **(206) 515 3629.**

Table 5-4

Minimum Required Drawings Schedule

MV ELWHA
Contractor Bid Support (CBS) Drawings
Cable Wiring List Spreadsheet
Propulsion Power Electrical One-line Diagram
PCS Installation Block Diagram
Propulsion Control Functional Block Diagram
24 VDC Power Supply Systems Installation Block Diagram
Propulsion Control Equipment Arrangement
Propulsion Switchboard Arrangement and Layout
SCR Drives Arrangement and Layout (with upgraded SCR cooling system)
EOS Console Arrangement and Layout
Pilothouse Console Arrangement and Layout
Certified Drawings for all equipment dimension, weight and foundation
Detailed Design Drawings and Engineering Calculations
Final CBS detailing any changes as a result of Detailed Design
Qualitative Failure Analysis (QFA)
Failure Mode and Effect Analysis (FMEA)
Design Verification Test Memorandum (DVTM)
Fault Current Calculation and Protective Device Coordination Analysis
Voltage Drop Calculation
SCR Cabinet Heat Load Calculations
Propulsion Switchboard Schematics Diagrams
SCR Drives Schematic Diagrams (with upgraded SCR cooling system)
EOS Console Schematic Diagrams
Pilothouse Console Schematic Diagrams
Vital Systems Power Supply Systems Schematic Diagrams
PCS I/O List

8.4 Contractor Bid Support

The Contractor shall prepare an appendix to be included with the WSF specification to the shipyard bidders for the shipyard work involved with the installation of the Contractor's systems, hereafter referred to as the "Contractor Bid Support" (CBS). This CBS shall be a compilation of all pertinent data required by the state to (1) properly ascertain the scope of work involved with the installation and testing of the propulsion Contractor equipment and systems for the purpose of shipyard's bidding on the work and (2) to provide mechanical drawings that spell out the physical installation of all components. The drawings shall contain complete material lists that, once finalized as part of the final CBS package, can be used by ship's operating crew and vessel engineering in identifying and locating installed components. The CBS shall include a complete equipment list giving every individual piece of equipment that requires separate installation, general arrangement drawings showing modifications to existing equipment (including internal layout of back panels and new control modules or devices being added), equipment dimensions and weights, foundation design requirements, simplified electrical one line drawings of propulsion electrical system (power, control and monitoring and alarm), cable lists with cable type for every circuit to be installed and wired by the shipyard and including all reused cables and cables to be removed, simplified one line diagrams for auxiliary support systems, details for piping connections, and special instructions or requirements as necessary to ensure that the shipyard is fully cognizant of the shipyard responsibilities and work scope associated with the installation of the PCS. A minimum set of drawings required can be found in Table 5-4.

The PCS design must be substantially complete as of the date of delivery of the final CBS to WSF. The Contractor shall be responsible for all costs associated with changes made by the Contractor to the design of the PCS after submittal of the final CBS, and which subsequently result in a Change Order from the shipyard. The CBS need not contain detailed schematics, wiring diagrams, piping A and D's, or other information not actually necessary for bidding purposes, but should contain such detailed information if available.

The CBS shall be delivered to the State for initial review and approval within 45 days of contract award. The final approved appendix with any changes from the review process shall be delivered to the State in an easily copied format by the date set forth in the Contract.

The format of the final delivered product shall be 8½"x11" pages for text, and 8½"x11" or 11"x17" for graphics and drawings. Larger format drawings shall be reduced to one of the sizes stated above. Text and art work shall be legible, sharp, and undistorted. All backgrounds shall be white.

8.5 Review of the Detailed Drawings and Engineering Calculations

Contractor shall submit to the state all Detailed Design Drawings and Engineering Calculations to the state within 77 days of contract award. A minimum list of such drawings can be found in Table 5-4. This submittal shall include a final set of CBS drawings per Section 8.4 of this specification.

The WSF Vessel Design Representative designated by the WSF Project Manager will examine the Contractor's detailed design and final CBS package to ascertain compliance with the Specifications. Drawings will be returned within 10 days of receipt with one of the following categories marked, as appropriate:

APPROVED
APPROVED SUBJECT TO COMMENTS
RETURNED FOR REVISION
REJECTED, NOT SUBSTANTIALLY COMPLETE

Unless fully APPROVED, all drawings shall be resubmitted for review and approval.

The WSF Vessel Design Representative's examination shall not be for the purpose of checking for errors or omissions in the Contractor's calculations, specifications, design or drawings, although they will be noted if found, but rather to ensure compliance with the intent and substance of the Contract and Specifications.

The WSF Vessel Design Representative will review each drawing submitted and indicate any changes necessary to secure approval. An appropriately marked copy of the transmittal memorandum will be returned to the Contractor.

Drawings which have been "APPROVED SUBJECT TO COMMENTS" need not be corrected until revisions are submitted. A fully approved drawing shall be obtained prior to the vessel being delivered to the shipyard.

Engineering Change Notices, used to implement design changes in manufacturing prior to submitting a revised design drawing for review, shall be submitted for review by Vessel Design.

No manufacturing of custom elements of the Contractors systems (enclosures, consoles, internal back panels, power supplies, and similar equipment) shall begin prior to the contractor receiving design review approval from Vessel Design.

Drawings and other documentation submitted for review and approval which are not complete, or are not accompanied by required supporting documentation or references will not be reviewed.

Rejected submittals do not count towards fulfilling the Contractor's obligations in regards to scheduling, i.e., a drawing returned REJECTED will have to be resubmitted complete within the scheduled time.

Three (3) paper copies of each drawing and one (1) CD are to be submitted to the WSF Vessel Design Representative, using a WSF approved Document Submittal form developed by the Contractor.

Engineering calculations shall identify the project, the drawing and system for which the calculations were performed, and the engineer who performed the calculations. Calculations shall be submitted to the WSF Vessel Design Representative for review and comment.

References to textbooks or other reference material shall be minimized. Formulas or constructions used shall be included in the calculations sheets, together with a complete explanation of symbols used.

If calculations have been produced using non-proprietary computer software, provide the data files on CD disks. Data files submitted on CD shall reflect the published hard copies exactly.

8.6 Software

All software and programs used in and by the PCS, diagnostics system, and individual equipment PLC's or similar controllers, shall be delivered to the WSF representative designated by the WSF Project Manager at time of final acceptance of the systems. Commented source code and detailed flow charts shall be provided with all non commercial programs. Both hard copy and CD disks of program files shall be delivered in duplicate.

9.0 TESTING

9.1 General Requirements

This Section defines the requirements for factory and shipyard testing of the PCS equipment and components to demonstrate satisfactory workmanship, operation, and compliance with the Specification.

The Contractor shall be responsible to test all the major components of the PCS prior to delivery to the installing facility. Factory tests should be performed at the manufacturers testing facilities. All test equipment required to adequately demonstrate proper design and operation of the device shall be provided. Testing shall be to the satisfaction of WSF Representatives designated by the WSF Project Manager and ABS and USCG when required.

The Contractor shall prepare testing procedures and a schedule of tests for approval by WSF. Test procedures shall incorporate all tests required by this specification, USCG, ABS and IEEE Std.45, Recommended Practice for Electric Installations on Shipboard, as well as the manufacturer's standard tests.

The Contractor shall commission the systems after installation in the vessel. The Contractor shall do pre-test inspections of the installation, including wiring checks, signal checks, alignment and component installation checks, as well as all other required commissioning functions, and shall certify that the propulsion equipment is ready for full testing by the Contractor. After Contractor tests have been completed, the Contractor shall certify that the propulsion system is ready and available for operation and testing by the installing facility as part of dockside trials and sea trials. Contractor shall submit to the state complete documentation of all tests performed.

Factory authorized technicians for each major component of the Contractor systems shall be provided by the Contractor for all system checks, testing and commissioning aboard the vessel. Contractor technicians shall be responsible for cleanliness of equipment modified or worked on by the Contractor during installation and testing.

9.2 Schedule and Memorandums

Submit a complete schedule/plan of required factory and onboard testing for each major component of the Contractor systems to the WSF Project Manager for approval at least 30 days prior to commencing initial scheduled testing. Prepare and submit to the WSF Project Manager for review and approval a complete schedule of required shipboard tests for the Contractor systems at the time of delivery of the final Contractor Bid Support (CBS) package.

The Contractor shall prepare a test memorandum for each test.

During each test, record all data on the approved test memorandum forms.

The Contractor shall furnish WSF two (2) copies of each test report and cognizant Authoritative Agencies one (1) copy.

9.3 Test Equipment and Instruments

Use the installed instruments for test data where possible. Provide additional or special instrumentation where needed for any tests, including temporary supports, piping, and wiring. If any test data appears to be erratic or inconsistent, recalibrate the instruments involved and repeat the test.

9.4 Pre-Delivery Sea Trials

The Contractor shall schedule with WSF a comprehensive system test of the existing propulsion system prior to the beginning of the shipyard dockside period. During such tests, the vessel shall be taken out of service. Maximum ratings of speed, voltage, current, temperature, pushing and pulling thrust, and any other respective ratings shall be observed during these tests. Vessel maximum speed, stopping time, and stopping distance shall be recorded as minimum performance benchmarks for the new system. Tests shall include items 1 through 7 of Section 9.8.1, Sea Trial Requirements.

These tests are also intended to aid the contractor in determining appropriate voltage, current, and speed limit settings that should be programmed into their control system. In no way will this testing be interpreted to mean that the contractor's new system need not meet or surpass all nameplate ratings mentioned in this specification. For example, contractor's system shall be rated for the full 6000A nameplate rating of each motor whether or not a current limit of 5500A is programmed into the software settings based on this pre-delivery system testing.

The Contractor shall conduct power quality analysis testing for the existing shipboard installation on M.V. Elwha. Analysis shall compare and discuss all results, clearly show the full spectrum of switchboard voltage and current harmonics and other power quality parameters, like sags, swells, transients, flickers, notching and noise. Power quality test reports shall be submitted to WSF, with a preliminary report of the initial test of existing conditions. Power Quality Analysis shall ensure that power quality parameters will not be worse than before installation of the new propulsion drive system

9.5 Propulsion System Component Testing

9.5.1 Propulsion System Factory Testing

Propulsion Switchboard Equipment

The Propulsion Switchboard Equipment's factory testing shall include, but not be limited to, the following:

Visual inspections

Verify that the switchboard component's construction is in accordance with the Technical Specification.

Check availability and marking of components in accordance with the relevant drawings.

Verify that all rating plates of main components of power circuits are in accordance with the specification.

Verify the wire size and wire markers.

Insulation Tests

Measuring of clearance and creepage distance.

Dielectric test of 375 Vac circuits and higher.

Measurement of bus insulation resistance.

Functional Tests

Check the operation of all grounding switches.

Check any mechanical interlocks.

Check current transformers.

Check voltage transformers.

Check ground fault protection.

Check the interchangeability of components.

Test control, measuring and protection circuits.

Verify the calibration of measuring instruments.

Verify the calibration of the protection devices.

Propulsion SCR Drive Equipment

The Propulsion SCR Drive Equipment's factory testing shall include, but not be limited to, the following:

Visual inspections

Verify that the SCR drive component's construction is in accordance with the Technical Specification.

Check availability and marking of components in accordance with the relevant drawings.

Verify that all rating plates of main components of power circuits are in accordance with the specification.

Verify the wire size and wire markers.

Insulation Tests

Measuring of clearance and creepage distance.

Dielectric test of 375 Vac circuits and higher.

Functional Tests

Check the operation of all grounding switches.

Check any mechanical interlocks.

Check current transformers.

Check voltage transformers.

Check ground fault protection.

Check the interchangeability of components.

Test control, measuring and protection circuits.

Verify the calibration of measuring instruments.

Verify the calibration of the protection devices.

Propulsion Control Console Equipment

The factory test of the Propulsion Control Console Equipment shall include, but not be limited to the following:

Visual Inspections

Verify that the console equipment is within the Technical Specification.

Check the grounding of components.

Check the availability and marking of components in accordance with the relevant drawings.

Verify that all nameplates of components are in accordance with the Technical Specification.

Verify wire size and the accuracy of the wire markers.

WSF Representative Attendance

The Contractor shall provide for the presence of WSF Representatives designated by the WSF Project Manager to witness all factory tests as well as the Integrated Test. The Contractor shall advise WSF 30 calendar days in advance of any factory tests and again 7 calendar days prior to the tests.

The Contractor shall be responsible to obtain any clearances or passes required for WSF attendance at the test site. The Contractor shall ensure WSF observers are provided with a detailed test procedure and test schedule of all testing to be performed during their stay. A Contractor representative shall be provided to accompany WSF personnel while at the test site. ABS, USCG, and other Authoritative Agency personnel shall be informed and accommodated at testing as necessary to fulfill Specification and Authoritative Agency requirements.

9.5.2 Propulsion System Shipyard Testing

Contractor shall be responsible for installing all factory assembled propulsion system components into the reused enclosures on the vessel. All internal mechanical and electrical modifications necessary to install contractor's equipment shall be the responsibility of the contractor.

The Contractor shall allow for the presence of WSF Representatives designated by the WSF Project Manager to witness all shipyard tests. The Contractor shall advise such WSF Representatives in advance of any shipyard tests 3 calendar days prior to the tests.

Propulsion Switchboard Equipment

The Propulsion Switchboard Equipment's shipyard testing shall include, but not be limited to, the following:

Visual inspections

Verify that the switchboard component's construction is in accordance with the Technical Specification.

Check availability and marking of components in accordance with the relevant drawings.

Verify that all rating plates of main components of power circuits are in accordance with the specification.

Verify the wire size and wire markers.

Insulation Tests

Measuring of clearance and creepage distance.

Dielectric test of 375 Vac circuits and higher.

Measurement of bus insulation resistance.

Functional Tests

Check the operation of all grounding switches.

Check any mechanical interlocks.

Check current transformers.

Check voltage transformers.

Check ground fault protection.

Check the interchangeability of components.

Test control, measuring and protection circuits.

Verify the calibration of measuring instruments.

Verify the calibration of the protection devices.

Propulsion SCR Drive Equipment

The Propulsion SCR Drive Equipment's factory testing shall include, but not be limited to, the following:

Visual inspections

Verify that the SCR drive component's construction is in accordance with the Technical Specification.

Check availability and marking of components in accordance with the relevant drawings.

Verify that all rating plates of main components of power circuits are in accordance with the specification.

Verify the wire size and wire markers.

Insulation Tests

Measuring of clearance and creepage distance.

Dielectric test of 375 Vac circuits and higher.

Functional Tests

Check the operation of all grounding switches.

Check any mechanical interlocks.

Check current transformers.

Check voltage transformers.

Check ground fault protection.

Check the interchangeability of components.

Test control, measuring and protection circuits.

Verify the calibration of measuring instruments.

Verify the calibration of the protection devices.

Propulsion Control Console Equipment

The factory test of the Propulsion Control Console Equipment shall include, but not be limited to the following:

Visual Inspections

Verify that the console equipment is within the Technical Specification.

Check the grounding of components.

Check the availability and marking of components in accordance with the relevant drawings.

Verify that all nameplates of components are in accordance with the Technical Specification.

Verify wire size and the accuracy of the wire markers.

WSF Representative Attendance

The Contractor shall provide for the presence of WSF Representatives designated by the WSF Project Manager to witness all factory tests as well as the Integrated Test. The

Contractor shall advise WSF 30 calendar days in advance of any factory tests and again 7 calendar days prior to the tests.

The Contractor shall be responsible to obtain any clearances or passes required for WSF attendance at the test site. The Contractor shall ensure WSF observers are provided with a detailed test procedure and test schedule of all testing to be performed during their stay. A Contractor representative shall be provided to accompany WSF personnel while at the test site. ABS, USCG, and other Authoritative Agency personnel shall be informed and accommodated at testing as necessary to fulfill Specification and Authoritative Agency requirements.

9.6 Commissioning Support

The Contractor shall work with WSF and the installing shipyard facility to complete the installation of and modifications to the PCS. Contractor shall include commissioning support to perform the duties of terminating external shipyard cabling, grooming such cable's conductors, inspecting, and wire checking.

9.7 Dock Trials

The Contractor shall work with WSF and the installing shipyard facility to develop a final schedule for installation and testing of the Contractor equipment. When the Contractor installations are substantially complete and appropriate commissioning and testing has been approved by WSF, the Contractor shall assist the shipyard during Dock Trials to perform preliminary tests and operation of Contractor systems.

9.8 Sea Trials

After successful Dock Trials and the installation of the vessel's machinery is complete and when the vessel is ready for sea, Sea Trials shall be conducted. The Contractor shall assist during Sea Trials, providing personnel to advise in the operation of the PCS, test and trials procedures to be performed during the Sea Trials, and to solve problems or fix failures in any Contractor equipment occurring during Sea Trials.

Additionally, one (1) week shall be set aside for special casualty testing and other tests as agreed between the WSF Project Manager and the Contractor. This shall be in addition to the five (5) day "No Fault" testing period and the In-Service Training.

The Contractor shall conduct power quality analysis testing for both the existing shipboard installation on M.V. Elwha before replacement, and for the new installation, after successful sea trials, during the shakedown period. Analysis shall compare and discuss all results, clearly show the full spectrum of switchboard voltage and current harmonics and other power quality parameters, like sags, swells, transients, flickers, notching and noise. Power quality test reports shall be submitted to WSF, with a preliminary report of the initial test of existing conditions and a final full comparison report as part of the "as-built" documentation. Power Quality Analysis shall ensure that power quality parameters will not be worse than before installation of the new propulsion drive system.

9.8.1 Sea Trial Requirements

Sea trials shall consist of, but are not limited to, the following:

(1) Progressive speed trials in each direction over measured mile, both ends.
(2) Single operation on each of the propulsion diesel/generators at 100% maximum continuous rating, or associated limit, for at least 60 minutes each.
(3) Master's landings and other desired maneuvers.
(4) Steering and maneuvering tests on both rudders.
(5) Crash stops on each propulsion motor, using all combinations of motors and diesel/generators.
(6) Crash reversal from full power ahead to full power astern on each propulsion motor, and on both simultaneously, and with one generator loss simultaneous with crash reversals.
(7) Half bridge response from simulated faults on other bridge half simultaneous with crash reversal.
(8) Operation of all auxiliary machinery and systems so that the system's capability to perform at rated capacity is demonstrated.
(9) General system testing shall be based on a Design Verification Test Memorandum (DVTM) and a Failure Modes and Effects Analysis (FMEA), separate from the special casualty testing specified elsewhere in these specifications. Examples: Loss of Generator, Loss of Main Motor, Ship Service Bus Tie Trip, and Design Verification Test items.
(10) Other tests or operations designed to show system compliance with the Specifications.
(11) Four hour full power endurance run in each direction.
(12) Demonstration of all propulsion plant configurations, i.e., half installed motor operation.
(13) Contractor shall subcontract a vibration analysis vendor to take detailed measurements of vibration experienced at the pulling bow motor for both ends. Contractor shall work in conjunction with vibration vendor to minimize vibration while optimizing motor's pulling torque during normal transit. Contractor shall submit all test reports and data acquired to the vessel SCE.

Various casualties shall be simulated in as realistic a manner as possible consistent with not placing personnel, the vessel, or any equipment in a dangerous situation. The casualty tests should check the system automatic responses, power, current, regeneration and other limiting functionality, quality of information presented to the watchstander, ease of manually initiating corrective procedures, and ability of the vessel to continue operation after single point failures. Contractor shall verify that all alarms, both audible and visual, shall report with their respective simulated failures.

The Contractor shall coordinate with WSF Project Manager to define the various casualty situations that shall be performed during the Sea Trials. After a final list is agreed upon, full testing procedures shall be developed by the Contractor and included with the test schedule required above.

9.9 Contractors Trials

The installing shipyard facility may perform trials as necessary for equipment and system pre-test, setup, and validation. These tests shall be used to determine that the systems are in working condition prior to conducting official Dock and Sea Trials.

The Contractor shall work in conjunction with the installing shipyard facility to schedule the trials to allow Contractor participation for the purpose of testing, adjusting, troubleshooting and validating the various components of the propulsion system, and to aid the installing shipyard facility in running Contractor equipment when necessary.

10.0 TRAINING

10.1 General Requirements

The Contractor shall provide classroom training for up to twenty (20) WSF personnel to include: The Construction Master, Chief Engineers, Assistant Engineers, Relief Chief Engineers, Relief Assistant Engineers, Design Engineer, Eagle Harbor Maintenance Technicians and Port Engineers. Subject matter shall be covered in detail with complete textbooks provided to each participant for each topic covered. Instruction shall be tailored to the particular requirements of the different WSF personnel attending the classes. The Construction Master will be most interested in the aspects of the propulsion plant that affect system control and casualty response. Engineers need detailed instruction on equipment operation, system capabilities, local, normal and emergency operating procedures, and maintenance and repair procedures. Design Engineer, and Chief Engineers and Maintenance Technicians also require detailed knowledge of the theory of operation, engineering design criteria, special features and fine details of control systems. At a minimum, classes shall include the following topics:

- Basic electrical theory of SCRs and AC-DC conversion, AC generators, and DC motors. This shall include design theory of operation and how this affects the physical configuration of the equipment.

- General theory and details of operation of the propulsion motor drives, firing controls and load controls. Emergency control, maintenance, and repair procedures shall also be covered.

- Basic theory and details of operation of the propulsion switchboard including manual and automatic generator paralleling, automatic speed and voltage controls, load limiting, load sharing, and governor controls.

- Pertinent safety precautions to be observed when operating or servicing equipment. Details and use of built-in safety features and any special safety equipment shall be covered.

- Basic theory and details of operation of maneuvering controls, indicators and alarms. Modes of operation, their affect on the various control units, meanings of all indications and displays, use of monitoring equipment, details of keypad use, and inter-relationship of the different systems.

- Both operating and design engineering personnel shall receive intensive computer training on the propulsion system computer controls and monitoring systems. Instruction shall be sufficiently detailed to allow engineering personnel to fully understand how the program functions, the effects of the operator's actions, how the program achieves desired results, the basic details of the algorithms used, and to be completely familiar with the operation of the terminals and controls.

- Use of reference material.

- Provide complete training on control software down to subroutines or module level. Use flow charts, source code graphics, or other tools to provide clear explanations. An emphasis shall be placed on motor control functions.

The Contractor shall arrange for, and cover all expenses of, a facility in which to conduct the classes at a location as close as possible to the shipyard facility to support including the actual installed systems in the training coursework.

The Contractor shall submit a course outline of the subject matter to be presented to the WSF Project Manager for approval. This outline shall be submitted at least sixty (60) calendar days prior to the beginning of classroom training. Classes shall provide intensive instruction in the operation, maintenance and repair of the equipment. Level of instruction shall be such that trained WSF personnel shall be capable of complete equipment maintenance (including major overhaul) and most repair work without need of factory representation. The Contractor shall provide to the WSF Project Manager six copies of any training DVD's that are available on the propulsion system equipment. These shall be delivered to the WSF Project Manager one week prior to the commencement of the local classes.

The Contractor shall also prepare a comprehensive training manual in accordance with the approved classroom and in-service course outlines. This training manual shall be used during training periods and remain the property of each student for later reference. The training manual shall be submitted for WSF approval at least thirty (30) calendar days prior to the beginning of classroom training. A copy of each manual submitted shall be provided on CD in MICROSOFT® Word™ format.

The class room training for the different groups of WSF personnel shall be scheduled to occur at specific periods related to the status of the propulsion system replacement. Classes shall be given at the following approximate times:

- 45 days prior to dock trials for each vessels system:

  One class of up to 20 people each
  Construction Master (1)
  Chief Engineers (4)
  Assistant Engineers (4)
  Relief Chief Engineers (2)
  Relief Assistant Engineers (2)
  Eagle Harbor Maintenance Electricians (2)
  Other WSF Personnel (5)

10.2 In Service Training

In addition to the classroom training specified above, the Contractor shall provide in-service training aboard the vessels for all operating personnel. These training periods shall occur after the ferry has completed and passed Sea Trials and shall be held in conjunction with crew training underway. In-service training shall be provided for all crews, for fourteen (14) days in duration. A Training Plan shall be submitted for the WSF Project Manager's

approval at least sixty (60) calendar days prior to the beginning of shipboard training periods. The in-service training course shall, at a minimum, address in detail the following subjects:

- Troubleshooting and maintenance procedures for equipment furnished.
- Maintenance scheduling (ship's plan)
- Tests and adjustments.
- Equipment performance evaluation.
- Pertinent safety precautions.
- Special tools and troubleshooting equipment.
- Equipment operation

During this time, the Contractor shall also conduct training on the vessel with its respective crew while underway using the approved Periodic Safety Test Procedure (PSTP) and Failure Mode Effects Analysis (FMEA) or QFA as the basis on which to perform emergency drills until the crews become proficient and automatic in their response to realistic casualties. Written procedures are then to be prepared by the Contractor in booklet form based on this training for each vessel as reference material for future crew members describing emergency conditions and the appropriate response.

Additionally, the Contractor shall assist each vessels crew members in the preparation of a Periodic Safety Test Procedure (PSTP). This shall include the provision of test kits, rigs and simulators.

10.3 Special Testing

During the fourteen (14) day In Service Training Period prior to placing the vessel back in service, the Contractor shall assist WSF in a 5 (five) day trials sequence, during which time the vessel shall be operated by WSF personnel. The vessel shall be operated under a variety of conditions and configurations, using various maneuvers, throttle command sequences, and control locations, all within the specified capabilities of the various systems. The system shall sustain no shutdowns or trips of the propulsion drives, propulsion generators, or PCS during the trial attributable to the Contractor's supply of equipment, systems, and software.

Any such shutdown or trip attributable to the Contractors scope of supply shall result in resetting the five day trial to the beginning of the sequence, and doing another five days of trials, until a full five sequential days of trials are completed with "No-Faults", to the satisfaction of the vessel Staff Chief Engineer. The WSF Project Manager has the latitude to waive any part of this requirement for a specific incident, and to continue the trial from that point until the end. If the five (5) day "No Fault" trial is not completed to the full satisfaction of the Project Staff Chief Engineer during the fourteen (14) day In Service Training Period, then the In Service Training Period shall be extended day-for-day, with no increase in price to WSF, until the trial is successfully completed.

11.0 ENGINEERING SUPPORT

11.1 General Requirements

During the shipyard installation period, it is the intent of WSF to require the Contractor to have personnel available on a full time basis for project management, contract administration, engineering liaison and consultation located in an office at the shipyard installing facility from the date commencing 30 days prior to the scheduled Delivery of the vessel to the installation activity and remaining until the vessel is returned to service.

The Contractor shipyard facilities will be included by WSF in the shipyard specification requirements. The Contractor shall include all his requirements pertaining to number of office spaces, desks, chairs, telephone service hookups, lighting, electrical receptacles, storage areas, and other specific office requirements as part of the CBS, and in a separate letter to the WSF Project Manager delivered concurrent with the final CBS.

11.2 Project Manager / Engineering Liaison

The Contractor shall staff the office with a project manager/engineering liaison available to WSF Project Manager for consultation during the design development of the PCS. The Liaison shall have the signatory authority to make decisions and commitments for the Contractor, to sign documents and approve drawings and engineering calculations for the Contractor. It is not necessary that the Liaison make on the spot decisions, but after proper consultation with cognizant Contractor personnel, the Liaison shall be able to deliver decisions and sign various documents with the full legal authority of the Contractor.

The Liaison shall have the ability to obtain project status and engineering related information on contract work requested by WSF in a timely manner. The Liaison shall work closely with WSF Project Manager to coordinate Project Management, manufacturing, testing, and delivery schedules. The Liaison shall be responsible for insuring all the contract deliverables are provided on schedule.

The Liaison shall be available, during normal working hours, on four hours notice to meet with WSF Project Manager. Additional duties shall include documenting design and construction progress of the Contractor system, addressing WSF comments to Contractor drawings, detailing test procedures for the installation period, coordinating Contractor technicians with installing shipyard activities work, and providing system installation and coordination information to the installing shipyard activity.

11.3 Seattle Liaison Office

The Contractor Design Liaison office, provided by the shipyard at their installing facility, shall be staffed full time (8 hours per day, 5 days per week, except legal holidays) from the day of vessel delivery to the shipyard installing facility until the vessel is returned to service. The installation liaison representative shall arrive at the shipyard no later than the day of vessel delivery and shall remain on permanent basis until such time as the ship completes final sea trials in Puget Sound.

12.0 SPARE PARTS AND SPECIAL TOOLS

12.1 General Requirements

Spare parts and special tools will be selected by the WSF Representative designated by the WSF Project Manager from the list of recommended spares and tools submitted by the Contractor. WSF selected spares shall be provided by the Contractor, labeled and packaged for long term heated storage, properly stored by the Contractor in a controlled atmosphere, and stowed aboard the vessel or delivered to the WSF warehouse just prior to Redelivery.

The Contractor shall provide a list of manufacturer's recommended spare parts and special tools for the PCS. The list shall include the minimum required spare parts and special tools, for each piece of equipment provided, necessary to support 24 calendar months of continuous operation by the MV ELWHA. This time period shall commence at the end of the Warranty period. The spare parts shall be installable by the various vessel's operating crews

Each part or component shall be identified and labeled by a unique part number that is clearly traceable to the parent equipment. If the complexity of the equipment necessitates, exploded views of the equipment and its components shall be provided in the final Spare Parts List to aid in the identification of parts.

Spare parts lists shall indicate the name, address, and telephone number of the source of the parts as of the day the list is submitted and, in addition, shall include its unique manufacturer's part number, quantity recommended, part or tool availability lead time, part or tool item cost, and identify the parts or tools parent equipment. The list shall include a recommendation for WSF owned inventory on-board the vessel, and ashore. Parts not recommended for WSF ownership, but retained as manufacturer's spare parts shall be priced and listed separately as "factory spares".

No WSF owned spare parts shall be used during commissioning tests, trials, shakedown or warranty periods. All parts required prior to the end of the warranty period shall be Contractor furnished as part of the original installation work.

12.2 Final Recommended Spare Parts List

The final recommended Spare Parts and Special Tools list shall be submitted to the WSF Project Manager for approval at the conclusion of system design and in sufficient time to ensure that the WSF selected Spare Parts and Special Tools are provided by the time the vessel is ready for Sea Trials. The final recommended list shall be sub-divided into those parts recommended for stowage on-board the vessel and those to be stored ashore in the WSF warehouse.

12.3 Delivery of Spare Parts and Special Tools

Upon approval of the list by the WSF Project Manager, the Contractor shall provide the selected Spare Parts and Special Tools, packaged and labeled by the manufacturer for shipment and long term storage. The Contractor shall hold the on-board spares in a clean, dry, heated, Contractor provided storage location, until delivery and stowage aboard the vessel just prior to Redelivery. Delivery of on-board spares to the Vessel and the ashore spares to the WSF Warehouse shall be as directed by the WSF Project Manager.

13.0 APPENDIX

13.1 Intent

The intent of this Section of the Specification is to list WSF guidance drawings and Vendor documents which shall be use by the Contractor in the design process of the new PCS as directed in this contract.

WSF Guidance Drawings represent the WSF concept for the proposed system. They are provided to aid the Contractor in his design task. Final details of the concept and design may be modified by the Contractor only with the written agreement and acceptance of the WSF Project Manager.

13.2 MV ELWHA Enclosure List

MV ELWHA Super Class

WSF DWG NO.	VESSEL	DWG TITLE	NOTES
8204X-578-090-01	ELWHA	Electrical One-Line Diagram	WSF
3828-050-01	ELWHA	Machinery Arrangements	WSF
8204-669-090-21	ELWHA	Propulsion Power and Distribution Rip-out	WSF/new
8204-669-099-21	ELWHA	PCS Functional Block Diagrams	WSF/new
8204-669-099-22	ELWHA	PCS I/O List	WSF/new
8204-669-099-23	ELWHA	EOS Console Elevation Arrangement	WSF/new
8204-669-099-24	ELWHA	Pilothouse Console Elevation Arrangement	WSF/new
8204-669-099-25	ELWHA	Main Propulsion Switchboard Elevation Arrangement	WSF/new

(END)

EXHIBIT 1

WASHINGTON STATE FERRIES

ELECTRICAL INSTALLATION SPECIFICATIONS

REVISED 09/02

ELECTRICAL MODIFICATIONS - GENERAL

New and modified electrical systems shall meet the following general electrical requirements:

A. Provide labor, material and equipment to mark each new or modified cable with its circuit number and cable type by use of a raised-letter embossed aluminum tag wherever a cable enters an enclosure of any type or penetrates a deck or bulkhead. Cables shall have identification labels on each side of deck or bulkhead penetrations and at any other location where both sides of the penetration are not readily visible for cable tracing. Care shall be taken that the correct cable tag is installed on each cable and in every location where required. Assign a unique cable number to each separate piece of cable installed by the Contractor. For circuits that branch, or are connected at junction boxes, lighting fixture, etc., the basic cable number shall remain the same through the circuit. A bracketed dash number (-X) identifier shall be appended to each individual cable or wire starting with the lowest number at the power or signal source and increasing to the farthest load of the circuit. Provide new power/lighting typed panel directory cards for panels that have new or modified circuits. The circuit designation and load description of the circuit shall be typed on the card to correspond exactly with the final as-built condition of the Vessel.

B. Provide labor, material, and equipment to mark each individual wire for all new or modified circuits with identification floaters. Floaters will not be required for power or lighting cables. These floaters shall be provided and installed and be white polyolefin with permanent black typewritten lettering. The floaters shall be RAYCHEM-TMS (Terminal Marker System) or equal. Hand written letters or wire marker tape floaters will not be accepted. The correct circuit number shall be indicated on one line of each floater. On the second line of the floater, the terminal identification number shall be shown. The terminal identification number shall consist of the termination block and the termination point identification and the individual conductor identifier within the cable. Spare conductors and jumpers shall also be fully identified by this method.

C. All control wiring terminations shall be made to terminal boards using ring lugs under compression terminal connections. No more than two (2) wire terminations shall be placed under each screw of a terminal board exclusive of jumpers. All terminal lugs shall be installed using a manufacturers approved controlled-cycle crimping device.

D. Each new or modified cable shall be tested for continuity. Record the origin and destination terminal designations to verify agreement with drawings for new, modified and/or relocated equipment and the approved electrical drawings. Record the date each circuit is checked, calibration date of the test equipment and the name of the person performing the test. Record actual resistance values observed during each test rather than noting that the value is satisfactory. After testing is complete, restore the system to operational status.

E. All cable provided and installed by the Contractor shall be Low Smoke per Mil-C-24643A. Open up and restore existing cable transits and wireways as necessary. Provide new penetrations when needed. Bulkhead and deck cable penetrations shall maintain the watertight and fire rating of the boundaries penetrated and shall be installed and suitably protected to satisfy USCG requirements. Provide new cable to reconnect existing equipment that was relocated due to this modification, if the existing cable is too short. Remove all existing cable rendered useless by this modification. There shall be no more than two (2) cables entering any relocated or reconnected light fixture.

F. In locations where cables will penetrate a bulkhead or deck, a USCG approved method, shall be utilized. In locations where stuffing tubes are used, the clear distance between adjacent stuffing tubes shall be no less than one and one half (1-½) the diameters of the largest stuffing tube of the two (2). Cables transiting bulkheads and decks shall maintain the fire-tight/water-tight capability of the bulkhead or deck as existing.

G. All new cable banding, and replacement of existing cable banding where disturbed by the work, for interior and exterior, shall be stainless steel, using flexible channel rubber between the banding material and the cable. The use of nylon ty-raps as cable retention devices will not be allowed. Unless otherwise specified, cable shall be installed in accordance with IEEE Standard 45, Clause 10 (except 10.11) and 13, and 46 CFR 111.60.

H. Route new cables in existing wire ways as much as practical. All new exterior cable hangers, clips and attachments shall be stainless steel. The entire vehicle deck, curtain plate, machinery casing exterior and the underside of the passenger deck shall be considered exterior surfaces.

I. All new fiber optic cable installations will be tested to the following requirements:

a) Test Equipment requirements. Optical time domain reflectometer (OTDR). The OTDR is used for estimating the attenuation rate of a fiber, and locating the nature and location of defects in an optical link.

b) Specified Limits. The cable is considered satisfactory if the maximum measured attenuation for each fiber does not exceed the vendor's attenuation data by greater than 1 db/km.

c) Acceptance/pre-installation tests. Fiber optic cable and associated components shall undergo visual inspection prior to installation in the cableways to verify that it is mechanically sound. Inspect fiber optic cable with OTDR to verify it is optically sound and within specified limits.

d) Installation tests. After the cable is installed in the cableways, the pre-installation tests shall be repeated to verify that fibers were not broken or damaged when the cable was pulled through the cableways.

e) Post-Installation tests. After all fiber optic cable topology links have been installed, tests using optical inspection with OTDR, shall be conducted to verify that the end-to-end attenuation of the fiber optic cable topology is within specified limits.

(END)